THE
CANADIAN ENGINEER

Published Weekly Established 1893

ISSUED IN THE INTERESTS OF CANADIAN CIVIL, STRUCTURAL, RAILROAD, MUNICIPAL, HYDRAULIC, HIGHWAY AND CONSULTING ENGINEERS, SURVEYORS, MINE MANAGERS, ENGINEERING—CONTRACTORS AND WATERWORKS SUPERINTENDENTS.

Index to Volume 27

JULY—DECEMBER, 1914

THE CANADIAN ENGINEER

Head Office, 62 Church St., TORONTO

MONTREAL WINNIPEG

INDEX TO VOLUME 27

JULY to DECEMBER, 1914

AUTHORS.

EDITORIAL.

ARTICLES.

PERSONALS AND OBITUARIES

BOOK REVIEWS.

Volume 27. Toronto, July 2, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

TUNNEL VENTILATION DURING CONSTRUCTION

IMPORTANCE OF CAREFUL ATTENTION—QUANTITY OF AIR REQUIRED — MODERN METHODS OF REFRIGERATION AND VENTILATION IN LONG AND DEEPLY OVERLAID TUNNELS.

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THE successful completion of over half a dozen long tunnels within the past 15 years has thrown much light on the ventilation and refrigeration of such tunnels during and after construction, and the progress of medical science, together with that of sanitary and mechanical appliances, has made possible for men to work, not only a few days, as, for instance, under the regime of the Cæsars, but for a lifetime, in tunnels subjected to high rock-temperature, deadly gases, and a high degree of humidity. The research work of the United States Bureau of Mines, in connection with the sampling and testing of mine and tunnel air, also that of inflammable gases and explosives, has added valuable information to that obtained from the driving of the long European tunnels.

Vitiation of the Atmosphere of Tunnels.—When exhaled by the human body, air contains about 4.4 parts of carbon dioxide and 15.4 parts of oxygen, as against 0.03 and 20.7 parts, respectively, when pure; thus, air exhaled by men, and incidentally by animals, is vitiated by a lack of oxygen and by an increase of carbon dioxide. A certain amount of water vapor is also expelled by exhaling and by the body, the amount depending on the percentage of humidity in the surrounding air. The amount of carbon dioxide excreted by the human body varies according to the degree of bodily activity; it has been estimated by various authorities that a man of average size gives out .6 to .7 cu. ft. of carbon dioxide per hour, but a man working hard gives out about 1.2 cu. ft. per hour. For certain practical purposes in connection with the subject treated in this paper, it is assumed that a tunnel-man, working under average conditions, excretes 1 cu. ft. of CO_2 per hour; practically similar conditions prevail with animals, and it has been determined that the amount of CO_2 excreted by a horse or mule is about 8.5 cu. ft. per hour.

Carbon dioxide to the extent of 2 per M. is not injurious to human beings or animals; as a matter of fact, human beings oftentimes spend several hours daily in rooms containing a larger proportion of CO_2 without experiencing discomfort. Railroad and street cars contain as much as 3 per M. of CO_2; cafes and theatres from 3 to 5 per M.; class-rooms up to 10 per M. Generally, however, little or no muscular efforts are exercised by people present in the above places; furthermore, their stay is relatively of short duration. In the Simplon tunnel, the amount of CO_2 varied from 0.5 to 7.5 per M. on the south side, and from 0.7 to 4.8 on the north side. Driving of the St. Gothard tunnel often proceeded with as much as 10 per M. of carbon dioxide.

The effects of carbon dioxide on men, animals and lights is quoted by different authorities to be as follows: Up to a content of 2 per M. of CO_2 in air, men and animals are capable of accomplishing hard and continuous work; with 10 per M. of CO_2, men are still able to work under normal conditions. without resenting ill effects; in a proportion of 50 per M., human beings are affected and lights burn poorly. Great danger for human beings when air contains 80 per M. of CO_2, and animals die when inhaling air with 130 per M. of CO_2.

The presence of gases has occurred not only in coal mines or coal-bearing strata; traces have been observed, and even large quantities of gases have been encountered in limestone, sandstone and shale formation, both in dry and wet tunnels. These gases, consisting chiefly of methane and hydrogen, are produced either by carboniferous, sulphuric or ore deposits, or by the chemical action of water, air, or both. Vegetable detritus and remains of dead animals lying on the ground surface, are carried by water together with air, into cracks or faults of the earth, where a chemical action takes place, and, according to the density of these gases and also of the structural formation of the ground, they either rise to the ground surface or penetrate deeper in the ground; whence their appearance in tunnels under construction.

In tunnel work, the daily consumption of some 800 to 1,000 lbs. of dynamite contributes largely to the vitiation of the air, especially in headings, where 50 to 80 lbs. of explosives are consumed per round, 6 to 8 blasts being fired in 24 hours. The effect on human beings of the gases of dynamite, consisting chiefly of carbon dioxide, carbon monoxide, nitrogen, and a smaller percentage of hydrogen and methane, is too well known to dwell upon here; poisoning, if not total asphyxiation, caused by inhaling some of the gases referred to above, has occurred only too frequently in ill-ventilated tunnels, and the engineer is confronted here with the complex problem of the preservation of life with a minimum consumption of time and power.

It is generally accepted that the explosion of 1 lb. of dynamite produces 3.4 to 3.6 cu. ft. of carbon dioxide. The burning temperature of nitro-glycerine has been found to be about 5,400° F., and it is estimated that the heat given out by the consumption of 1 oz. of dynamite was about 135,000 B.T.U.; yet, from observations made

in tunnels of small cross-section and in headings, where the consumption of explosives was high, it has been found that their influence on the air temperature was very small; due undoubtedly to the rapidity with which their combustion takes place, and owing to the low specific heat of their gases.

The methods that serve the purpose of increasing the speed of driving long tunnels, involve a large amount of materials to be drilled, blasted and removed, thus producing much dust, which naturally also adds to the discomfort of tunnel-men. In driving the Loetschberg tunnel, as many as 560 lin. ft. of holes were drilled in

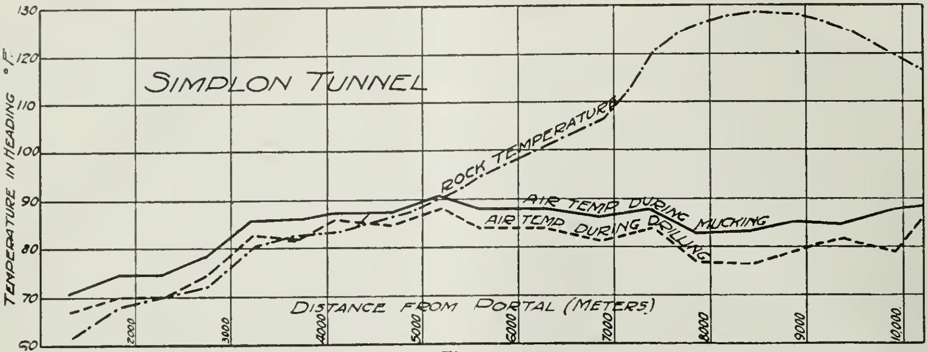


Fig. 1.

The removing and hauling of excavated and other materials necessitate the use of a large number of work trains. In the Simplon tunnel, for instance, 24 trains were usually run per day; in the Loetschberg tunnel, the traffic was still more intense, there being one train every

24 hours in the heading (limestone formation), thus causing some .75 cu. ft. of rock to be pulverized every hour, and when, in addition to this, some 500 to 600 yds. of materials were excavated daily, a large amount of dust was forcibly carried away by the powerful ventila-

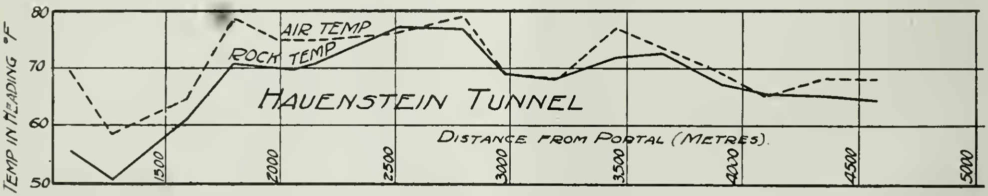


Fig. 2.

45 minutes; that is, 30 to 34 trains per day. Under similar conditions it becomes evident that the use of steam locomotives becomes prohibitive, for, besides being of no assistance to ventilation, like compressed-air locomotives, which in some cases exhaust from 2 to 5 per cent. of the total volume of the air introduced in a tunnel, they generate heat, gases and steam. The gases consist chiefly of carbon dioxide, nitrogen, some carbon monoxide and sulphur fumes. Gasolene locomotives have

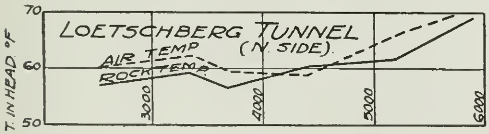


Fig. 3.

been used quite extensively, and when run properly they do not present such inconveniences as do steam locomotives. Under normal conditions, the gases exhausted consist of nitrogen, carbon dioxide and water vapor. When run in such a way as to cause incomplete combustion, the gases exhausted contain an appreciable amount of carbon monoxide, and in several instances this inconvenience has justified their abandonment.

tion. The introduction of water-core drills, together with the practice of sprinkling the muck before handling it, is a marked improvement in tunnel work. Certain materials, when drilled and blasted, give out less dust than others. For instance, mica-shist, and in general tough rocks, produce less dust than more brittle ones, like granites or limestones. The practice of allaying dust is

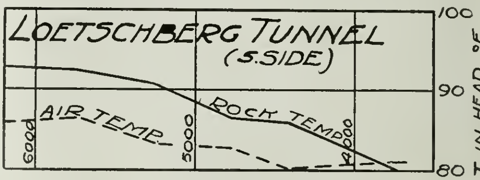


Fig. 4.

to be recommended, not only for the sake of the tunnel-men's health, but also to reduce the wear of tools and machinery.

The presence of candles, oil and acetylene lamps in a tunnel affect also to a large extent the degree of purity and the temperature of the air. In long tunnels as many as 300 to 500 lamps are used daily, and a consumption of 400 to 500 lbs. of oil or calcium carbide is not un-

usual. It is estimated that the amount of CO_2 produced by oil and acetylene lamps is about .8 and .53 cu. ft. per hour, respectively. The use of acetylene lamps is increasing rapidly in connection with tunnel work, and they are to be preferred to oil lamps, for, in addition to giving out less CO_2, the heat produced is about 7,500 B.T.U. per hour, more or less, according to the size and make; that is, about one-half only of that given out by oil lamps.

Heat Radiation of Human Beings and Animals, and Humidity of Atmosphere.—It is well known that the human body, also that of an animal, gives out a certain amount of heat by exhalation and by radiation, the amount depending upon atmospheric conditions and also on the degree of bodily activity; more heat is generated by a man accomplishing hard work than by a man at rest. As the result of various observations, it has been determined that with an air temperature of 70 to 80° F. the amount of heat given out by the human body is 10,000 B.T.U. per hour; that of a horse of average size, 95,000 B.T.U. per hour.

The proportion of humidity in the atmosphere plays also an important part in connection with the vitiation and temperature of the air in which tunnel-men are called upon to work. Human beings feel best when, at an average normal temperature, the percentage of humidity is 50 to 60 per cent. Everyone has observed that, when perspiration does not take place freely, a feeling of uneasiness is experienced; the greater the humidity, the greater the discomfort. It has been determined that the amount of water perspired by a man, at 84° F. and a percentage of humidity of 6, was 4 oz.; with the same temperature and 81 per cent. humidity, the weight of water perspired was only .85 oz. Men worked in the St. Gothard tunnel at a temperature of 86° F. and with 100 per cent. humidity; in the Simplon tunnel the percentage of humidity varied from 70 to 98; in the Loetschberg tunnel the humidity was high, reaching 100 per cent.

Miscellaneous Agencies Affecting the Purity of Tunnel Atmosphere.—In addition to carbon dioxide expelled when exhaling, foul or bad odors are excreted by the stomach or the body of men and animals, due either to improper digestion or uncleanliness. Unsanitary conditions, inadequate toilet facilities and poorly-drained tunnel stables for horses are all agencies contributing to the vitiation of the air in tunnels. Where a large quantity of timber is used, decaying or rotting of same, together with other agencies of lesser importance, all add to the evils above referred to.

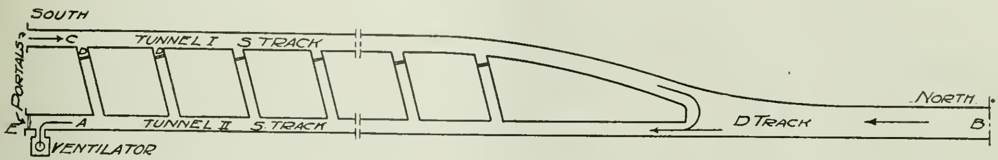


Fig. 5.

The quantity of carbon dioxide allowed or advocated nowadays in working chambers or zones of long tunnels varies from 1 to 2 per M., according to the conditions prevailing; under normal conditions, i.e., when the rock temperature and the consumption of explosives lie within reasonable limits, the last-named figure can be used, but when the rock temperature reaches 90° F. or more, and when 60 to 70 lbs. of explosives are consumed per blast, in heading work, it is advisable to keep the proportion of CO_2 within 1.5 per M. In the presence of methane or other explosive gases, it becomes necessary to keep the proportion of CO_2 within 1 per M.

Methods of Ventilation.—In driving long tunnels, little reliance can be placed on natural ventilation, for, even with a powerful artificial ventilation, the seasonal air temperature variations are but little perceptible in a tunnel, save within a relatively short distance from the portal. In the St. Gothard tunnel, for instance, no fluctuation in the air temperature was noticeable 3,500 ft. away from the north portal; in the Simplon tunnel, seasonal variations of the air were quite perceptible for a distance of 2,000 ft.; but 6,000 ft. away from the portal the temperature fluctuations were hardly perceptible. This tends to show that little attention can be paid to external high and low air temperature, and that weight should rather be given to the average yearly air temperature.

Although the basic method of ventilating short tunnels varies greatly, it is rather surprising to note that the plenum method has been used almost exclusively in driving some 10 tunnels from 2 to 12 miles long; this is due chiefly to the fact that conditions not met with in driving short tunnels are encountered in driving long ones. For instance, the driving methods used in connection with the last-named tunnels necessitated that fresh air should be distributed along various working sections of the tunnel, and in order to cool the air in the bore within a practicable limit, fresh air had to be supplied to the heading or other points within a very short time after leaving the fan or blower, so as not to be subjected to heating when coming in contact with the walls of bore, oftentimes warmer by many degrees than the air supply. The necessity also of using, for mechanical, construction and economical reasons, a primary ventilating system, consisting of fans located at the tunnel portal, and of blowers and injectors for the ventilation of the heading, are some of the reasons for giving preference to the plenum method of ventilation during construction. Yet, a combination of the plenum and

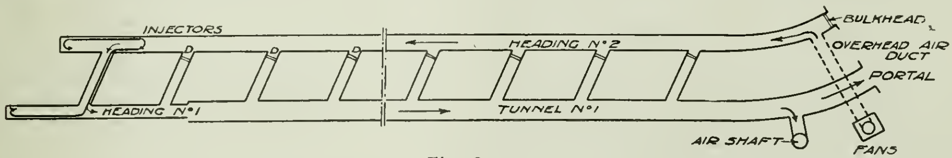


Fig. 6.

vacuum methods has been used in a few isolated cases, or when the portal ventilators were to be part of the system to be used in connection with the permanent ventilation after construction.

Quantity of Air Necessary for Ventilation During Construction.—This is by no means a matter of guess, as is often believed and done; erroneous assumptions have led to a lack of adequate ventilation in a few instances and to a waste of power in others. The amount of air necessary to overcome the evils caused by the agencies referred to in the first part of this paper can

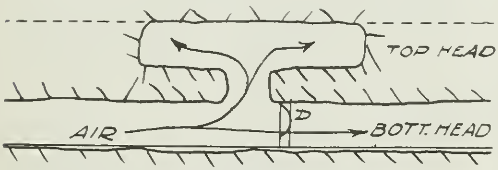


Fig. 7.

be based: (1) On the amount of carbon dioxide excreted or produced by men, animals and lights. (2) On the amount of CO_2 produced by the consumption of explosives. (3) On the heat generated by the presence of men, animals and lights. (4) On the heat occasioned by the temperature of the rock penetrated. (5) On the gases liable to be encountered during the driving period. (6) On miscellaneous agencies affecting the condition of air.

Then in formula 1, A equals 13,582 cu. ft., B = .002, C = 2,400,000 cu. ft., D = .0004, and Q is found to be 6,087,500 cu. ft. per 24 hrs., or 4,320 cu. ft. per min.

Should now the rock temperature be high, and the consumption of explosives very considerable, B should be made .00175, or even .0015. Using these figures in the above example would make Q equal to 5,330 and 6,840 cu. ft., respectively.

Formula 1, if used to determine the amount of air necessary for heading ventilation, would give results altogether too low to meet the requirements of heading work. In driving long tunnels, the field of operation is spread over a large zone, extending over a distance of several thousand feet, and blasting occurs at several points, as against one face only in heading work; also, the mining crews, timbermen, masons, etc., are distributed in small groups of ten to 50 men, in a room of large cubic contents. In a heading, altogether different conditions prevail. Here we have some 20 or 25 men with lights, cramped in a room 60 to 80 sq. ft. in cross-section and 100 to 150 ft. long; the consumption of explosives varies from 50 to 90 lbs. per blast, according to the material penetrated, and when 6 to 8 blasts are fired daily, as little time as possible can be lost after firing so as to enable the mining crews to resume their work. According to the efficiency of heading ventilation, the time lost or spent idly by the men, waiting for fumes to clear off after a blast, varies from 15 min. to one hour, 30 to 40 minutes being a fair average. In such cases, the amount of air necessary for adequate ventilation cannot be based on the amount of carbon dioxide excreted or

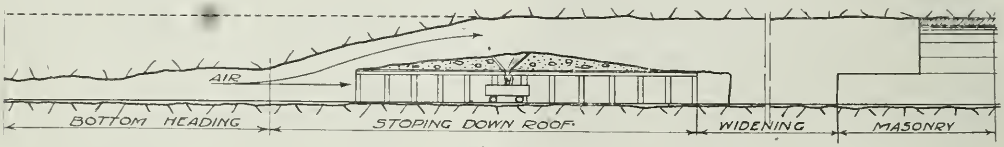


Fig. 8.

The vitiation of tunnel air referred to in items 1 to 4, inclusive, can be estimated with reasonable accuracy for all practical purposes, but the conditions brought on by agencies such as are referred to in items 5 and 6 can only be provided for by making a reasonable allowance for contingencies, and the judgment of the engineer, together with that of the geologist, should govern in this matter.

For nearly all practical purposes the amount of air necessary for the ventilation of a long tunnel during construction, exclusively of that for the ventilation of the heading, can be expressed by the formula:—

$$Q = \frac{A\,(1 - B)}{B - D} - C \quad . \; . \; . \; . \; . \; . \quad (1)$$

Where Q = amount of air, in cu. ft. introduced into the tunnel in 24 hrs.;
A = total amount of carbon dioxide, in cu. ft., given out in 24 hrs, by men, animals, lights and explosives;
B = amount of carbon dioxide allowed in tunnel air;
C = cubic contents (in cu. ft.) of the tunnel section in which crews are working;
D = cubic contents (in cu. ft.) of carbon dioxide in one cu. ft. of air, generally taken as .0004 cu. ft.

Example: In a tunnel driven under fair conditions, 3 shifts of 300 men, each with acetylene lamps and 4 horses, are employed, and 500 lbs. of explosives are consumed per 24 hrs. The tunnel crews are spaced over a length of 6,000 ft., and the tunnel has a cross-sectional area of 400 sq. ft. Carbon dioxide is not to exceed 2 parts in 1,000.

produced by men, animals and lights, but chiefly upon the consumption of explosives in one blast; also on the rock temperature and the gases encountered, if any.

The following formula, if used with judgment, will be found of assistance in determining the amount of air to be forced into a heading:—

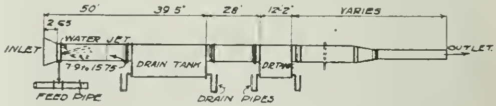


Fig. 9.

$$Q = \frac{\dfrac{A\,(1 - B)}{B - D} - C}{T} \quad . \; . \; . \; . \; . \; . \; . \quad (2)$$

Where Q = amount of air, in cu. ft., introduced in the heading per minute;
A = amount of carbon dioxide, in cu. ft., produced by the consumption of explosives in one blast.
B = amount of carbon dioxide specified for the air in the heading at the end of time, T.
C = contents of heading in cu. ft.
D = .0004.
T = time from explosion of round until resumption of work in heading (in minutes).

Example: In a heading 7 x 10 ft. in cross-section, and 300 ft. long, the consumption of dynamite per blast is 60 lbs.

• The men are to work in an atmosphere containing not more than .002 of carbon dioxide, twenty minutes after firing a blast.

Then in formula 2, A equals 210, B = .002, C = 21,000, D = .0004, T = 20, and Q is found to be equal to 5,500 cu. ft. According to the conditions prevailing, Q can be made larger or smaller by giving B or T different values.

The total quantity of air to be forced into the tunnel is the sum of the value for Q as given by formulæ 1 and 2, or in the example selected = 4,230 + 5,500 cu. ft. = 9,730 cu. ft. An allowance of 20 to 30 per cent. should be made for contingencies.

The amount of air to be forced by, and the capacity of the ventilators depends to a large extent on the type of drills used in driving a bore. The Mont Cenis and St. Gothard tunnels were driven solely with the assistance of the ventilation produced by the exhaust of air-drills; the ventilation thus available was poor, however, and insufficient in many instances; yet these bores were completed without other means of ventilation. The rock temperature in these tunnels was not very excessive, and the driving progress very slow. On the other hand, the capacity of the ventilating plant of the Simplon tunnel was remarkable for its magnitude, necessitated by a high rock temperature and by the total absence of air-drills, water-drills being used in the heading, and hand ones in the enlargement. The use of air-drills, and practically the complete abandonment of hand drilling in connection with the driving of recent long tunnels, besides enabling more progress to be made at a lesser cost, has become a valuable auxiliary to tunnel ventilation. In the Loetschberg tunnel, from 4 to 6 large Ingersoll Rand drills and as many as 15 hammer air-drills were used. In the Hauenstein tunnel there was as many as 40 drills at one end of the bore.

Fig. 10.

Fig. 11.

Table 1 gives the amount of air introduced into the south side of the Loetschberg tunnel by the ventilating system, together with that of drills and locomotives; thus 7 to 22 per cent. of the total amount of air introduced into the tunnel was exhausted from the drills, while that introduced by the air locomotives was as high as 5.4 per cent. of the total. As a matter of fact, later on, 50 per cent. of the air introduced into the bore was exhausted from the drills. This fact is to be kept in sight, for it demonstrates in a most convincing way that, instead of using a large amount of power for the ventilation alone, it is more economical to use power that will operate drills first, and then be still of utility for ventilating purposes.

From others and the writer's observations, it has been found that, for low rock temperatures, up to, say, about 90° F., the air temperature in a tunnel or heading is 5 to 7° higher than the rock temperature, and also that the air temperature reached a maximum during mucking (see Figs. 1, 2, 3, 4). At this very moment, that is just after firing a blast, the drillers are busy setting up their drills, the muckers are loading the blasted material into cars as rapidly as possible, thus the necessity of doing away with the fumes of explosives in a minimum lapse of time.

Refrigeration of Tunnels during Construction.—It is beyond the scope of this paper to go into lengthy details pertaining to the refrigeration of long tunnels during construction; however, let it be pointed out briefly that the cooling of air by air is only possible or economical within a certain limit. In the Simplon tunnel, for instance, this limit was reached when the air temperature in the tunnel was 100° F. In order to cool the tunnel by the introduction of fresh air, when the rock temperature is high, it would be necessary to force in a large amount of cool air from outside; but, as the size of ventilating pipes or conduits is limited to certain practical dimensions, depending on the room available, the velocity of the air conveyed by these would soon reach too high a velocity; the friction would increase rapidly, thus generate heat, and the air would reach its destination at too high a temperature to be effective for refrigerating purposes. Should the fresh air supply be a few degrees warmer than the rock temperature when reaching the heading, it would have little cooling effect, if any, on the air temperature. Fortunately, in most cases, the ventilating air has a lower temperature than that of the rock. With a high rock temperature of, say, 100° or more, other means of refrigeration have to be resorted to. As it is not proposed to describe here the methods that have been or are being used to ventilate long tunnels in each case, the reader is referred to Table 2, giving the characteristic features pertaining to the ventilation of 12 tunnels 12,000 to 65,000 ft. long; yet it is interesting to review the methods advocated or used at various epochs of modern construction.

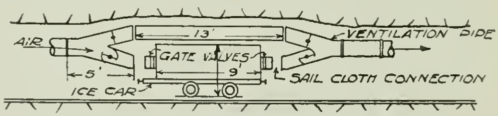


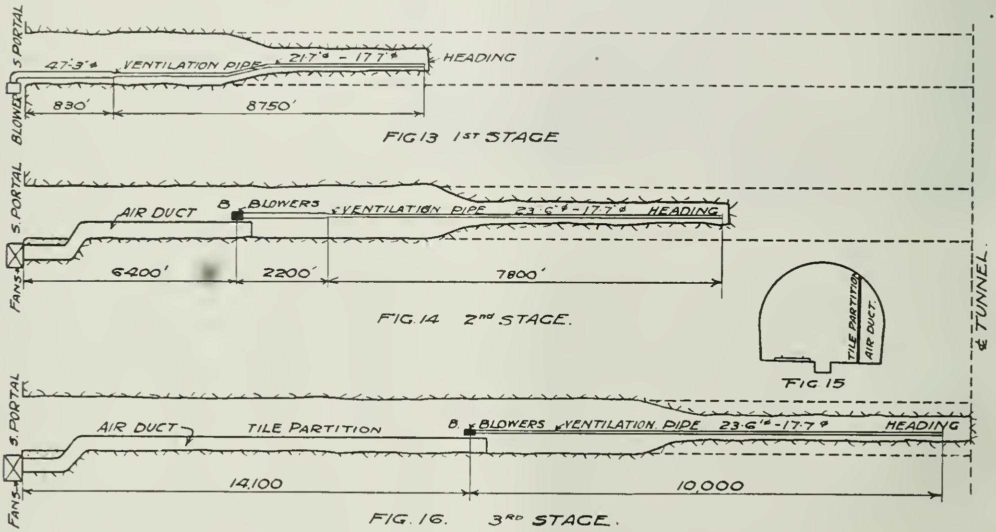
Fig. 12.

The experience gained in driving the Mont Cenis and St. Gothard tunnels had demonstrated clearly the inconvenience caused by inadequate ventilation, and when the driving of the Arlberg tunnel was started, an elaborate ventilating plant was provided at each portal. On the east side of the bore, where air-drills were used, the capacity of the plant was 5,300 cu. ft. per minute, and on the west side, where water drills were used, 6,350 cu. ft. Iron pipes served as means of air conveyance. Later on, the capacity of both systems was increased to 12,600 cu. ft. per min.

In 1891, when the Simplon tunnel project was considered anew, it was estimated that, having regard to the high rock temperature to be expected (107° F.), an adequate system of ventilation would be required, and the following plan of construction was advocated (Fig. 5). From the north portal to about half-way between portals the tunnel was to have a cross-section accommodating two tracks; the bore would then branch off in two single-

track tunnels extending to the south portal and connected at intervals with cross galleries. During construction, on the south side, a ventilating plant at the portal of Tunnel 2 was to exhaust the vitiated atmosphere of Tunnel 1 through the cross galleries; Tunnel No. 2 was to be closed at the portal by a bulkhead, E. Thus, fresh air would rush in at C during construction, and also at B after completion of the tunnel. During the driving period the cross galleries, except that nearest to the heading, were to be closed by bulkheads, D. On the north side, the ventilation was to be provided by forcing in air from the portal through a 31.5-in. diam. pipe. It was estimated that, theoretically, 56 cu. ft. of air per sec, and per h.p. could be forced in through the ventilating pipe, and 9.5 cu. ft. per sec. and per h.p. through the double tunnel system on the south side. Thus, for equal power consumption, the intensity of the ventilation would be 17 times greater with the double heading system than with the ventilating pipe. Later transverse gallery next to the heading's face. Power-driven blowers were used also to some extent, but with little success. The intake end of the injectors was located in heading No. 2, and one pipe conveyed air to each heading. Each injector consisted of a nozzle through which 3.8 cu. ft. of water was discharged per min. at 1,100 lbs. pressure and 280 ft. vel. per sec. About 2,100 cu. ft. of air was thus forced per minute, at 5.6 oz. pressure, through 300 ft. of 15.7 and 8-in. diam. pipe. As many as four injectors were installed on one conduit, 1,300 ft. long.

Owing to the increase in temperature, the primary and secondary ventilating systems soon became inadequate, and the following methods of refrigeration were resorted to: In heading No. 2, 21 water sprays (Fig. 10) were installed, forming a water curtain 65 ft. deep, through which passed the air, forced in by the portal fans. The air thus cooled off, but containing much humidity, was forced through wire screens located in



Figs. 13, 14, 15 and 16.

on it was decided to drive two single-track bores between the end portals.

Ventilation and Refrigeration of the Simplon Tunnel as Actually Built.—The primary ventilating plant consisted of 2 fans, 12.3 ft. in diam., each driven by a 200 h.p. hydraulic turbine, located at the portals (Fig. 6). When running in parallel, the capacity of the fans was 105,900 cu. ft. per min. at 5.7 oz. water pressure. Air was forced into heading No. 2 and exhausted through Tunnel No. 1, being conveyed from one bore to the other through the gallery nearest to the heading's face, and the others closed by a bulkhead, D.

In order to ventilate the top heading, a sailcloth curtain (Fig. 7) was provided at each upraise to deflect the air current upwards. In the very hot sections, however, the ventilation of the top heading became so inadequate that, instead of driving a top heading, it became necessary to stope down the rock, overlaying the bottom heading, on a timber platform (Fig. 8). This method of ventilation was found to be more effective, the air being thus given a better circulation through both the top and bottom headings. The secondary ventilation consisted of water injectors (Fig. 9) installed at the front of the sprays. This system, although very effective, was a serious hindrance to traffic, and it was superseded by that illustrated in Fig. 11. The above appliances enabled air to be cooled by about 17° F., the temperature of water used for spraying purposes varying from 39 to 62° F., according to the season.

In order to cool the air conveyed by the ventilating pipes in the headings, ice cars were branched on the ventilation pipes (Fig. 12) and air forced through these. Each car contained 513 vertical tubes 1½ in. diam., 31 in. long, presenting to the ventilating air a surface of 540 sq. ft. This cooling system necessitated twelve ice cars per day; after five months' use it was abandoned altogether, being too costly and very cumbersome. In addition to the above refrigerating systems, perforated pipes located at intervals in the tunnel or headings served the purpose of sprinkling the walls of the bore with cold water.

From observation it has been determined that in heading No. 1, for instance, when the rock temperature was highest (130° F.), the cooling effect due to air and water supplied for this purpose was as follows: During drilling 11.6 B.T.U. were absorbed per sq. ft. of rock

surface and per hour, and during mucking 6.4 B.T.U. per sq. ft. per hour.

Ventilation of the Loetschberg Tunnel.—The system of ventilation used on the south side of this bore will be described only, that on the north side being similar, although somewhat less elaborate.

pipes varying in dia. from 47.3 to 17.7 in. At intervals, water injectors were provided on the pipe, and, as work progressed, the masonry duct and the secondary ventilating plant, the latter being carried on trucks (Fig. 17), were moved forward. According to the rock temperature, as many as 3 electrically-driven blowers were pro-

TABLE I.

Date.	Air exhausted by drills. Cu. meters.	Per cent. of total.	Air exhausted by locomotives. Cu. meters.	Per cent. of total.	Air exhausted by ventilation. Cu. meters.	Per cent. of total.
June, 1909	105,680	7	18,720	1.2	1,382,400	91.8
September, 1909	102,000	7.2	19,000	1.3	1,300,000	91.5
December, 1901	132,000	18.8	26,000	3.7	542,000	77.5
March, 1910	132,000	18.8	30,000	4.3	538,000	76.9
June, 1910	132,000	22.2	32,000	5.4	430,000	72.4
September, 1910	132,000	14.1	23,400	2.5	777,600	83.5

TABLE II.

o.	Name of tunnel	Length of tunnel Feet	Over-laying depth Feet	Rock Temperature Deg. F.	Air Temperature Deg. F.	Explos. consumption Lbs. 24 hr.	Air for ventilation Cu. ft.	Power consumption H.P.
1	Simplon	65,042	7,100	130	96	1,100	76,000	400
2	St. Gothard	49,147	5,570	87	87	660	4,200	...
3	Loetschberg	47,680	5,200	94	86	1,000	34,000	350
4	Mt. Cenis	42,142	5,430	85	86	440	2,100	...
5	Aarlberg	33,600	2,360	65	..	770	12,600	250
6	Ricken	28,200	1,740	78	77	500	8,400	200
7	Granges	28,093	2,880	72	70	600	8,000	150
8	Arthus Pass	28,060	1,000*	..	..	500	3,000	55
9	Tauern	27,965	5,150	74	..	450	12,360	420
10	Albula	19,240	2,370	59	..	...	2,000	30
11	Bosruck	15,630	3,530	48	..	500	12,360	280
12	Weissenstein	12,136	1,640	55	55	300*	6,000*	...

* Denotes approximate figure.

During the first construction period, that is, until the tunnel had reached a length of about 11,500 ft., the ventilating plant consisted of 2 Capell blowers (Fig. 13), located at the portal, and having a total capacity of 4,200 cu. ft. per min. at 10.8 oz pressure. Air was forced through wrought-iron pipes, 47.3 in. diam. at the blower outlet and 17.7 in. in the heading. When the pipes had

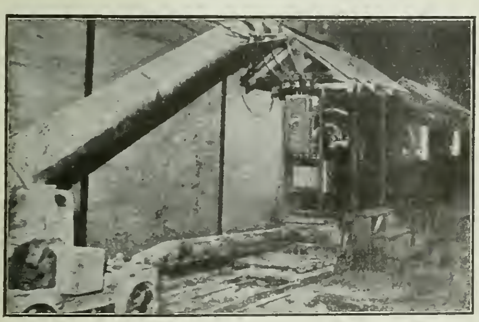


Fig. 17.

reached a length of 7,300 ft., two water injectors were installed on the pipes, this system being used until the tunnel reached a length of 11,500 ft., and as many as 4 injectors were used on the air conduit. Soon after the ventilating plant, which was to be used during the operation of the tunnel, was put in operation; it consisted of two fans, 11.5 ft. diam., driven by 175 h.p. electric motors, and having a total capacity of 106,000 cu. ft. per min. at 5.7 oz. pressure. Air was conveyed in the tunnel through a duct of 68 sq. ft. area (Figs. 14, 15 and 16), consisting of blowers "B" of 100 cu. ft. capacity per sec., taking air from the main ventilating duct and forcing it through the heading at 3.8 oz. pressure through

vided on the ventilating pipe. When available, large quantities of snow were also introduced into the tunnel. During construction, the primary ventilation was found to be of too high a capacity, and the air supply was reduced to 10,000 cu. ft. per minute.

No.	Type of Haulage	Size of vent. pipes Head	Enlarg't	Type of Drill	Type of Lights	Number of men per 24 hr.
1	Air loc.	8"	15.75"	Water	Oil Acetyl.	800
2	Air / Steam	none	none	Air	Oil	400
3	Air	17.75"	47.25"	Air	Acetyl.	1000
4	Horses / Steam	none	none	Air	Oil	250
5	Horses / Steam	E. 19.75"	W. 15.75"	Water / Air	Oil	700
6	Horses / Steam	13.8"	31.5"	Air	Oil Acetyl.	400
7	Air		23"	Air	Acetyl.	550
8	Gasolene / Electric	9"	16"	Air	Acetyl. Electric	250*
9	Electric / Benzine	19.7"	31.5"	Water	Acetyl. Electric	400*
10	Horses	—	—	Water	Oil	—
11	Steam	11.8"	19.4"	Air	Oil Gasolene	300*
12	—	13.75"	23.6"	Air	Oil Acetyl.	500

* Denotes approximate figure.

Conclusions.—For tunnels 25,000 to 35,000 ft. long, a ventilating system consisting of fans at the portals, forcing in a large quantity of air at low pressure, and of power-driven blowers and water injectors, for the ventilation of the heading, will be found amply adequate in most instances; for, let it be pointed out here, that there exist a relation between the length and the mass, or height of material overlaying a bore; one can hardly conceive a short tunnel very deeply overlaid.

For double-track tunnels, 40,000 to 50,000 ft. long, when the rock temperature is not expected to exceed 100° F. by many degrees, a duct system similar to that used in the Loetschberg tunnel will prove ample and feasible in most cases. For longer tunnels, where a high

rock temperature may be encountered, the double-bore system, consisting either of 2 single-track tunnels, or of a double-track tunnel with an auxiliary bore of smaller dimension, driven parallel to and connected at intervals by cross galleries with the main bore, may have to be resorted to.

LAYING OUT SIDE HILL ROADS.

THE following method of laying out contour grades for side hill roads is from a paper written by Capt. A. C. Gardner, Chief Surveyor, Land Titles Office of Saskatchewan for the Regina Engineering Society. At the outset he emphasizes the desirability of the engineer appointed to such work being thoroughly practical, and claims the following as valuable assets: a good knowledge of the country, as to climatic conditions, nature and extent of the different seasons and general requirements, also a well developed faculty for recognizing suitable road locations.

A few years ago, in addition to probable amount of traffic, the most serious question was to obtain a satisfactory road at much below minimum cost of suitable construction and the views of the engineer had in many cases to be sacrificed, in order not to exceed the amount allowed. At the same time some kind of an outlet for traffic had to be provided, and that in many cases quickly. This state of affairs was unfortunate, as a certain amount of discredit has been reflected upon the engineers who had to lay out roads of this nature, and who are entirely blameless as to excessive grades and poor locations. The engineer has generally a choice of locations, the first considerations in choice being the most direct, easiest grade, minimum cost of construction and up-keep. This choice can readily be determined with a climometer and the assistance of one or two men. Whether starting from the valley or upland, very often a good idea of feasibility of location can be determined in the following manner, viz.: Starting at the approximate point of commencement and sighting on some conspicuous point at the approximate outlet, the angle of elevation is read and knowing the distance approximately between the two points it is a simple mathematical problem to work out what the probable grade would be and if results are at all satisfactory much time has been gained. These rough shots are worth trying if they can be taken. In any event, having decided where the engineer will try and get his location the practice would be to put on an angle of elevation or depression (as the case may be) which gives about two-thirds of the maximum grade intended for the road, the rodman is then instructed to take up points from one to three hundred feet apart and at all prominent points encountered along the preliminary grade line, rough stakes are driven temporarily to mark the points above mentioned. Whilst engaged in this work careful notes should be taken as to the suitability of location, where the grades can be altered to advantage, location of springs, number of culverts required for proper and effective drainage, suitability of road for traffic at all seasons of the year, whether the road would be easy of construction or otherwise, and many other points of more or less importance. The author usually accomplished the reconnaissance work in from a few hours to one or two days, depending on the length of road and the difficulties to be overcome. In some cases, having run the preliminary grade and finding the outlet unsuitable, he would choose a suitable outlet, and starting there, run in a reverse direction, generally meeting the first grade at some point on the way up or down (as the case might be). Having decided upon the location by the above means, the author next had his men cut the necessary number of stakes. These were about 1½ inches in diameter and 18 inches long, and blazed on both sides (material usually easily obtainable at or near location of this kind). In the meantime he would probably walk over the location several times, taking notes as to final location. A little difficulty is encountered at first in setting up an instrument on hillside work and some care is required to avoid disturbing the adjustments of same after it is set up, but this is soon overcome by practice.

Method and Practice of Staking Final Location.—First have the rodman cut a rod about 1 inch in diameter, cut square across at both ends and peeled or blazed, the length of rod equal to the height of axis of telescope from the ground (the instrument being set at height suitable to the observer) usually from 4½ to 5 feet. The instrument is then set up at point of commencement and the height of same guaged by rod., i.e., rod on ground and top reaching axis of telescope, the instrument is levelled and angle of elevation (or as the case may be) to give the required grade set off on vertical circle and telescope clamped. About thirty-four and one-half minutes gives a one per cent. grade. The rodman then starts off with a bundle of stakes holding one crosswise on top of his rod and moves up or down the hill till the observer sees the stakes cut by the horizontal hair. Stakes are numbered consecutively and driven by another man following along the line. This man also keeps the rodman supplied with stakes. The interval between stakes is from 15 to 20 feet where hillside is uniform and at closer intervals where pronounced irregularities are encountered. So long as the line of sight is direct and grade uniform, the line can be staked for a considerable distance from one station, when the line begins to swing appreciably either towards the observer, or the reverse, or where it is desired to change the grade, the next station is taken up over the last stake set and instrument set up in the manner previously described; all sharp and short turns are run in either level, but in any case not exceeding a one per cent. grade. A slack grade is always put on at the outlet of the road, particularly if the bulk of heavy traffic is going up hill. Where a uniform grade could be obtained for any considerable distance, the author usually broke same in several places unless the ground admitted of a very slack grade in the first instance. At all runways or wherever he intended placing a culvert, a long stake would be placed about the centre of the proposed road, the rod was held on top of same and stake driven until the top became grade, the stake was then marked "culvert" and dimensions stated on one side, and on opposite side of stake was written "grade; fill to top of stake." It is often necessary to go back over portions of the staked line improving the grade wherever possible. The grade can easily be determined at any point where it is desired to commence a change by setting up over stake at this point and then directing the rodman to go backwards and forwards about five or six stakes. The telescope is then directed on cross stake on top of rod and clamped. Angle is then read on vertical circle, and as a further check the rodman then moves forward holding rod at foot of each stake set. If the horizontal wire cuts stake held on top of rod in each case you have the grade from angle given on vertical circle in the first instance. The changing of grade does not occupy much time once the line is established. Having staked the grade the writer would then engage a farmer and have him plough a furrow along the line of stakes where the hillside was open, using one of the men to either hold the plough or drive the horses, and

going along with them would see that the line of stakes was closely adhered to and a suitable furrow made. This left an almost permanent grade line, even if the stakes were knocked down or fell out. The furrow was not necessarily through the bush, as a clear-cut line was always made which could be easily picked up for a considerable time afterwards, and stakes were not liable to be disturbed.

To ensure a satisfactory road being built, it is advisable (if possible) for the engineer to have the road foreman with him when he stakes the grade or before he leaves the ground, and by going over the line with him and pointing out how he will be able to strengthen the road and round out the bends, also how to work from the staked line or furrow (and if a practical man) he will in a few hours thoroughly understand what is required and how to carry out the work.

In making the survey of the road the writer usually ran the line so that the road foreman, in order to keep within the limits of roadway, practically had to follow, not only closely to grade, but also required to straighten road and round out bends. It is, of course, advisable for the engineer to be on the ground at least a portion of the time during construction. The author was seldom able to do this, but by taking the above precautions most of the roads he laid out were satisfactorily constructed.

The longest and most satisfactory side hill which he laid out by the methods above described is about 2¾ miles in length. Maximum grade 5½ per cent. with an average grade of about three per cent. or slightly under. All the curves are practically level and several of the shorter turns are level. There is one small timber bridge which eases out a very sharp bend and avoids a large spring, situate about one-quarter of the way down hill. The road was constructed under the supervision of a Mr. J. Bird, road foreman and contractor.

At the time, construction of this road was considered expensive. It did not, however, cost any more, if as much, per mile, as some of the roads constructed on the uplands where many ponds or sloughs were encountered.

It would be out of place in this paper to discuss the usual methods of staking out side hill roads beyond stating that in comparison, it is practical, economical, rapid and easily picked up at some future time as this location remains much longer defined on the ground, and if marked in the manner described it is apparent to anyone what the grade will be (i.e., easy or otherwise). Considerable time in the past often elapsed between location and construction. To somewhat support this statement, the following is an extract from the report, 1909-10, of the late Mr. E. W. Walker, District Surveyor and Engineer, Department of Public Works, Province of Saskatchewan. (Mr. Walker, in speaking of methods, means the usual method of staking centre line and putting in slope stakes).

"The shortcomings of these methods, as I see them now, are that this work is often done so long before the road foreman and grading crew begin operations, that the stakes with their markings, as planted by the engineer, have disappeared, and the engineer is called upon to replace and re-mark these before the work of grading can be commenced properly, and it therefore tempts the road foreman to go ahead with the grading, disregarding the stakes if he has to replace and re-mark them from the engineer's diagram which, in many cases, he doubtless does not fully understand or appreciate."

According to a recent statistical report laid before the aldermen of Montreal, within the last four years, the city of Montreal has spent approximately $100,000,000.

TOWN PLANNING.

In a paper entitled "Housing and Town Planning," read by Christopher J. Yorath, A. M. Inst. C.E., M. R. S. I., city commissioner of Saskatoon, at the Calgary convention of the Alberta Town Planning Association, June 16, 17 and 18, the two chief problems with which civic improvement organizations have to contend were severally dealt with. Concerning bad housing, the primary causes were given as follows:

(1) Lack of proper legislation;
(2) Lack of sympathy between landlord and tenant;
(3) Insufficient education; and
(4) Overcrowding due to want of proper transit facilities and the number of houses allowed to be built on an acre of land.

The author dealt at length with these evils and went on to show how the questions which usually face the problem of housing reform are dealt with in Great Britain. He summarized the position of housing as it is at the present day as follows:

1. Unhealthy areas and dwellings exist which can and must be dealt with by the local authority.

2. Houses unfit for human habitation must be made fit for human habitation at the cost of the landlord, if necessary the local authority carrying out the work.

3. The provision, where insufficient, of more dwellings for the working classes, either by the local authority or through building societies.

Town Planning.*—In the building of every city there should be some object in view, some aim towards which those who are responsible for its foundations and growth are consciously aiming. Unfortunately, in the majority of cases the aim has been an unconscious one with the result that cities have grown up in a haphazard manner and many a beautiful spot turned into an ugly accumulation of bricks and mortar. Until recent years, it was thought that the checkboard system of planning was all that could be desired, but anyone who has studied the subject of town planning will realize at once that it is a failure and has necessitated even in what are known as the New World Cities, large expenditure to rectify some of its many defects. How can a system be called a plan which does not take into consideration local characteristics such as the undulation of the ground, a winding river, thickly wooded spots and other amenities.

It invariably happens that town planning is not thought of or put into operation until a certain amount of development has taken place. In Great Britain this does not interfere to any great extent with the planning for the future, as the undeveloped land is not staked out into lots and held by numerous landholders, but is usually in possession of a few; whereas in Canada, owing to the checkboard system and the selling of outlying plots far in advance of the time when the land is ripe for development, the proper planning of the future is rendered far more difficult and in many cases the difficulties will be so great as likely to make a scheme impracticable without special legislation.

A city attractive by its beauty, by its artistic symmetry and design and by the amenities and conveniences which it offers, will gain a reputation and an individuality of which not only its council and its landowners but also its citizens may be proud.

The aim of every city should be the one implied by the term "Garden City," beautiful, well planted and finely

*[This section of Commissioner Yorath's paper is given practically in full.—Editor.]

laid out, known and characterized by the charm and amenities which it can accord to those who seek a residence or dwelling removed from the turmoil, stress, and discomforts of a manufacturing district.

The various systems of planning which have been adopted in the past are rectangular, radial, and circumferential and curvilineal, but the latest schemes for town planning are generally a combination of all three, which allows for the best fulfilment of town planning ideals.

Essentials in Making a Town Plan.—The most essential points for consideration in the drawing up of a town plan are:—

(1) A general survey of past growth, present conditions and future possibilities.

(2) The preparation of a map of the city and its environment showing the configuration and undulations of the site, etc.

(3) The entrances to the city by water and land.

(4) The direction of main, radial and circumferential avenues and boulevards.

(5) Transportation.

(6) The layout and construction of avenues, drives and boulevards.

(7) The appearance and furnishings of the streets.

(8) The provision of parks, open spaces and recreation grounds.

(9) The administrative or civic centre.

(10) The defining of areas from a residential, industrial and commercial standpoint.

(11) The architecture of buildings, the space about same, the limitation of houses per acre, and the height and character of same.

(12) The design of water, sewerage and tramway systems.

Survey of Past, Present and Future Growth of City.—Before commencing a town plan it is necessary that the town planner should make a complete survey of the site and make himself thoroughly acquainted with local conditions. He should consider the rate of development of the city in the past and whether conditions will be such that its rate of development will be as great or greater in the future and what the main factors governing its growth and expansion will be.

In framing the town plan for Saskatoon, the writer had consideration for the following:—

(*a*) That the population had increased from 113 in 1903 to 30,000 in 1913.

(*b*) That it is the geographical centre of the fertile portion of the province of Saskatchewan.

(*c*) That it is served by the three principal Canadian railways and has a distribution area of 48,000 square miles.

(*d*) That a large terminal elevator is being constructed by the Dominion Government, and the city is likely to be the large wheat collecting centre for the Hudson Bay route.

(*e*) That owing to its being in a position to obtain cheap power from the large gas fields in Western Saskatchewan, it is likely to increase in importance as a large manufacturing and distributing centre.

(*f*) That, having the University and Agricultural Experimental Farm, it will be the educational centre of the province.

Having regard to all these circumstances, it was decided to plan the future growth of the city for a population of 250,000, with facilities for further extension without impairing the general design.

Map of City and Its Environments.—Many of the once beautiful sites which some of our cities now occupy have been wantonly spoiled by the worst form of vandalism and the lack of a proper system of planning instead of providing a setting and vista by which the beauty of monumental and public buildings may be shown.

The second step preparatory to the drawing up of a town planning scheme is to make a contour map of the site with contours showing the rise or fall of the ground every five to ten feet. The map should be drawn to a scale of not less than 400 ft. to an inch, and in addition should show existing trees, places of historic or local interest, railways, existing residences, public and industrial buildings, waterways, etc. The map should also show any towns or villages in the vicinity of the city, which may possibly become in the future, part of the city, together with the most important main roads or trails leading to or from the city.

This map will enable the town planner to lay down the main radial and circumferential avenues so that the important transit routes are linked up one with the other in such a manner as will avoid traffic congestion in the centre of the city. It will also enable him to preserve places of beauty, the water front, and to establish the most important buildings in commanding positions; to design his storm and sanitary sewers so as to obtain the maximum amount of gravity flow and to arrange his water supply in the most suitable zones so that the whole system of public utilities can be built up in units, which will ultimately become parts of a completed whole.

In Canada the preparation of this plan is more costly and entails a far greater amount of work than the preparation of a similar plan in Great Britain, as in the latter country the Ordnance Survey, which is carried out by the government, is complete in every detail, even to the showing of lamp posts on the streets.

The Entrances to the City by Water and Land.—After having secured a plan of the town or city as it actually is, the town planner should become thoroughly acquainted with its approach by land and water, so that he can lay the foundation of his scheme from these points in such a way that the visitor as he approaches the city will be immediately impressed by its civic dignity and beauty.

The water entrance may be from the sea; by river; or by lake and gives innumerable opportunities (owing to its varied characteristics) of special treatment, and cannot be too carefully studied before finally settling upon the scheme which will for all time be the chief characteristic by which the city is known.

How often is the water front spoiled by being entirely occupied by quays, warehouses and railways, when with a little judicious planning the whole could have been so planned as to make a commanding entrance. Space can be provided for all without disfiguring the natural beauty of the site; the quays can be made to follow the graceful curves of the shore and spacious esplanades provided to break the monotony of continuous lines of warehouses. If the ground should slope towards the water front much can be done by terracing, boulevarding and parkways which will add dignity and beauty to the site. By grouping the principal buildings and providing spacious and well-planted boulevards leading to and from the main front, a facade will be provided which will at once impress upon the mind the civic splendor and harmony in style.

Again, the graceful winding river so often found running through the heart of a city should be jealously guarded as the most beautiful asset which a city can

possess. Its banks can be made beautiful by the planting of trees, if they are not already wooded, and parks, terraces and boulevards provided which will be the most cherished belongings of the community. Sometimes the banks are flat, with large stretches of mud and the stream is very sluggish. This defect can often be remedied by formation of embankments and the land reclaimed formed into river-side parks.

Saskatoon has the South Saskatchewan River running through its centre with well-wooded and gradual sloped banks. In the town planning scheme which has been prepared by the writer, provision has been made along both sides of the river to form drives and boulevards, so that eventually when the scheme is completed a continuous drive of over 14 miles in length will be provided.

Again, the entrance to the city over the river by means of bridges should be considered from the architectural and scenic point of view. The whole beauty of the river may be spoiled by the construction of inartistic bridges, whereas they should be made to harmonize with their general surroundings. Every bridge over a river should be made a monument to the town.

Main, Radial, Circumferential Avenues and Boulevards.—The planning of the main, radial and circumferential avenues forms the skeleton upon which the town plan is built up, the minor and residential streets filling in the detail.

The main avenues, including the encircling boulevards and radial avenues bear the heavy traffic as they are usually the shortest means of transit between important points such as railway depots, quays, industrial and manufacturing districts. These avenues usually contain a street railway and should be made of sufficient width not only to take heavy traffic but also that they may be made attractive by means of boulevards.

In many of these avenues the street railway is laid in the centre of a boulevard with shaded walks on either side. By this method of construction a considerable sum of money is saved as compared with the system of paving the whole width of the track, and in addition a very much quicker means of transit is obtained as the railway is not hampered by the ordinary traffic of the street.

In planning out the widths of main roads it is difficult to estimate what the future will demand, but in any case it will be better to err on the wide side rather than the narrow.

The various types of streets usually required in a city are:—

(*a*) Main traffic avenues with tramways and boulevards (width from 100 to 200 feet).

(*b*) Secondary traffic avenues without provision for tramways (80 to 150 feet).

(*c*) Semi-residential avenues with provision for side and centre boulevards (width from 80 to 120 feet).

(*d*) Semi-residential avenues without provision for tramways but with side and centre boulevards (width from 80 to 100 feet).

(*e*) Residential avenues without provision for tramways but with side and centre boulevards (60 to 80 feet).

(*f*) Secondary residential avenues (width from 40 to 60 feet).

Transportation.—The most rapid and direct means of transport from and to important parts of the city is one of the chief considerations in the framing of a town plan, and emphasizes the necessity of developing the city's transportation facilities as a whole, and not as is often the case, the independent development of railway, water and interurban transportation. This latter method often entails very large expenditure in linking up the different systems in order to increase the efficiency of transportation. It is now realized in all large cities that enormous sums of money can be saved by commerce and industry if rapid means of transit are provided; and in many cities underground subways and elevated railways have been constructed in order to relieve congestion and provide this very essential requirement to aid the economic expansion of trade.

The Appearance and Furnishings of the Streets.—While it is essential and necessary in a town planning scheme to make provision for wide streets and to control the architecture of buildings, it is also important to remember that all objects in the streets, utilitarian or otherwise, are things to be seen, part of an organic whole, each having its respective part and place.

The furnishings of a street usually consist of street lighting posts, direction posts, telegraph and telephone poles, street railway poles and overhead wires, police patrol and fire alarm systems, letter boxes, public conveniences, advertisements, placards, etc.

It can easily be conceived and readily understood that if all these poles and erections on the street are neglected and allowed to be erected haphazard and without regard to artistic taste that no matter how much care may be taken in the upkeep of boulevards, and the control of architectural design that the general appearance and harmony will be spoiled.

The civic authorities and town planners should therefore give as much consideration to the details of street furnishings as to the development of the town plan if they wish to obtain the best results. The street lighting posts should be properly designed and appropriate in style; the street railway posts should also be artistically designed with ornamental base, etc. In many cities on the continent of Europe these posts, in the summer, are very much improved in appearance by flowers and drooping creepers hung from a basket fixed round the post.

Wherever possible, telephone and electric wires should be placed underground, as not only are the poles and wires a great disfigurement, but the poles occupy valuable space and they are a considerable source of danger to the public.

Parks, Open Spaces and Recreation Grounds.—In locating open spaces and parks, special consideration should be given to the preservation of places of natural beauty, such as wood, waterways, etc., and by the adoption of a town plan a young city can make provision for parks, etc., at very much less cost than would be the case in later years when building development has not only spoiled many beauty spots, but increased the value of land to a prohibitive price.

It is important that there should be ample reservations of open spaces, public parks and pleasure grounds, as without these "lungs" the health of a city must be very much impaired.

Although an endeavor has been made from time to time to fix a ratio of park area with population, up to the present there is no accepted ratio, as local conditions vary to such a large extent. In the United States it has been found that in cities with populations over 100,000 the number of persons per acre of park varies from 11,000 to 27,000.

With the checkboard system of planning, a large amount of valuable ground is often wasted in the unnecessary provision of paved streets and passages. By carefully planning the main and secondary avenues, through

traffic can be avoided and residential districts can be laid out in a far less costly manner, part of the space occupied by paved streets being utilized for open spaces, tennis courts, and children's playgrounds.

People's parks are universally provided on the continent, which contain sufficient acreage to include a complete natural landscape, typical, as far as possible, of rural country.

It has become a very general rule in making arrangements for the development of land on modern lines in Great Britain to stipulate that one acre in ten shall be set aside as public, or semi-public open spaces—this in addition to limiting the number of houses per acre.

In addition to the large people's parks, open spaces should be provided in each locality where games and recreation can be enjoyed by the people without having to travel any great distance from their homes.

The enjoyment of parks and open spaces is very much enhanced if they are connected and linked up with a system of park drives or boulevards.

The Administrative or Civic Centre.—The administrative or civic centre, which is usually the heart of a town or city, should be the dominating feature of the city. It is not only necessary to secure a central location, but also, if possible, to select a site which will provide a vista from several points of vantage.

The civic centre should be dignified and impressive, whilst at the same time in harmony with the characteristics of the town itself, and in keeping with the resources of the public.

The buildings, if possible, should be grouped along the water front, or if a winding river runs through the city, a site can usually be selected which will not only be central but which can be viewed from several points in the city. By the grouping of the administrative centre along a water front stateliness of architectural treatment can be obtained which is impossible when grouping the same buildings along a street.

The Architecture of Buildings.—The architecture of buildings is an important factor in the success of a town planning scheme, and is a distinct phase of civic æsthetics. In order to obtain harmony in design, plans should be submitted to some central authority of all buildings intended to be erected, showing proposed elevations. It is essential that a maximum height of a building under certain conditions should be fixed. In London and many places in Great Britain it is now established that a building shall not exceed in height the width of the street upon which it fronts.

In order to obviate overcrowding, it is essential that a maximum number of houses per acre should be adopted for different grades of property.

In limiting the number per acre it should be sufficient, in the case of land that is not planned out in detail, if it be stated that the rule should be so many houses to the acre; but the requirements of the local authority would be satisfied if the average number was obtained over a certain area with due safeguards for the space about each house not being too small. There should also be a maximum number of houses stated, more than which should not be erected on any one acre.

Thus, if the number limited was 12 to the acre, the local authority might be satisfied if on any ten acres no more than 120 houses were built.

In residential areas the height should also be limited. Houses should not be built more than three stories or more than a maximum height, to be defined.

METHOD OF FIXING TIME FOR THE PERFORMANCE OF CITY CONTRACTS FOR STREET IMPROVEMENTS.*

By G. L. Bennett, M.M.E., New York.
Efficiency Engineer Board of Estimate and Apportionment.

THE determination of the number of working days which shall be allowed for the completion of a given contract is a problem upon which little data is at present available. Where the contract is very largely for work on one sort alone, such as paving, the problem is simple; but where as in the grading of streets, a number of really different sorts of work, often requiring equipments partly or wholly different for each sort, is covered by the one contract, the amount of time which is proper to allow, is really a quite complicated problem.

Contracts commonly arise from demands which in themselves are either urgent and set for a particular time of fulfilment or are more complaisant as to time, requiring only ultimate completion within rather wide time limits.

Contracts of the former type, for emergency work or for supplying necessary links in larger schemes, can, in proportion to their needs, afford to sacrifice economy for dispatch. Contracts of the latter type, which includes a majority of street improvement work, can properly afford to disregard time as such and to seek economy of total costs alone.

There are comparatively few pieces of work which can only be economically accomplished by the use of some one particular equipment and of some one particular method. In general, there are a number of equipments and of methods which, depending upon the genius of those in control for management under the conditions obtaining, will yield economical results, but will require somewhat different times for completion. Leaving out of account variations in required time, due to such causes, there is, for each sort of work, some number of working days, more than which could not economically be used by the contractor. Thus, on a pick and shovel job, the employment of less than a certain number of men would not be economical because of the cost of the foreman and superintendence and therefore, in this case, the use of more than a certain number of working days by a contractor would be uneconomical. The same thing applies to any job for which an equipment and force are provided sufficient to complete that job in one of the perhaps several most economical ways so far as contractor's costs are concerned; and to this somewhat varying time may be applied the term, "Contractor's Economical Time."

It is to be recognized that small total contract quantities, in general, only warrant the employment of light and easily moved equipments and that, somewhat progressively, as the quantities become larger, more and still more effective equipments are warranted.

But this may be modified considerably by the amounts of work of this same sort or sorts which have been done or are yet to be done, in the locality of the contract in question. Thus a rather small contract for rock excavation could properly be given a shorter contract time in the northern part of Greater New York where the rock excavation is constantly in progress than it could somewhere out on the shores of Long Island or southern New Jersey.

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*Paper presented before the Municipal Engineers of the City of New York, February 25, 1914.

The amount of equipment to be employed is seriously effected by the costs of labor and the ease of procuring equipment. Where satisfactory labor is expensive or difficult to procure, contractors will, in general, employ machinery of a type which otherwise would only be used on much larger contracts, resulting, of course, in a shorter Contractor's Economical Time. Where machinery can be easily hired, equipment will often be used on small jobs such as could not otherwise be afforded. This affects also very large jobs for which, where no satisfactory disposal can be made of worn machinery, equipment is often provided only in such quantities that it shall all be practically worn out when the job is completed.

The total cost of the work rather than the cost to the contractor is the matter which interests the engineer in his capacity of manager for the party contracting for the work. And the total cost is, of course, the contract price plus the costs of surveys and designs, plus the costs of inspection, superintendence and interest on the moneys invested by partial payments or otherwise, all of which latter vary nearly directly with the time taken for the work.

The cost of interest, inspection, etc., will decrease, therefore, with a decrease in contract time, but because of the greater cost of equipment, etc., necessary to complete the work in less than the contractor's economical time, the contract price will tend to increase. That time which will give the minimum total costs for the work and which should accordingly on this sort of contract be used as the contract time, will therefore be somewhat shorter than the contractor's economical time.

Two methods of ascertaining the time to be allowed were open:

(1) By the balancing of inspection, superintendence, interest and similar time charges against the increased costs of obtaining and operating equipments of more capacity than are required to complete the contract in the contractor's economical time, using that point with reference to time which gives the least total cost, as the correct time to allow for the contract.

(2) By plotting the times allowed on previously completed contracts composed mainly of one kind of work and which had, in the judgment of the engineers in charge thereof, been prosecuted vigorously and with adequate equipment, a series of curves of quantity with reference to time can be drawn for each kind of work, each curve recognizing in its equation some particular controlling factor of variation. Having such curves and knowing the total quantity of work to be done, the proper contract time for this can be ascertained and the results can be combined to give the time for a contract including various kinds of work.

The operation of the first method for arriving at the contract time can be shown diagrammatically by Fig. 1.

In Fig. 1 the curve of contractor's costs shows the variation in cost with the contract time; the curve of interest, inspection and other time charges, the variation of these with contract time and the curve of total costs which has for its ordinate at each point the sum of the ordinates of the other two curves at that point, the variation of both with the contract time.

As these curves do not show variations with regard to quantity or other conditions governing any one sort of work, one such set of curves is necessary to determine the proper contract time for each total quantity of each kind of work. The contract times so obtained can later be plotted against the total quantities, even as has been done for Model 2, as shown in Figs. 2, 3, 4 and 5.

It is to be noted that this method depends upon a curve of contractor's costs, which can be determined, point by point, for the total quantity and the kind of work to which this curve applies, only by designing the most efficient plant or equipment to do this amount of this kind of work in each of the varying times assumed and from the use and costs of these plants or equipments, arriving at the contractor's costs.

That there is a very considerable difference in judgment as to the most economical plant for any given contract time and total quantity of work to be done and still more difference as to the delays and other items summed up in the contractor's costs must be apparent to those who are familiar with the variations in bid prices on those works of such magnitude as call for new and specially designed equipments.

And that the very considerable variation in bid prices between the various bids received for any contract is not all due to differences in the profits which the different

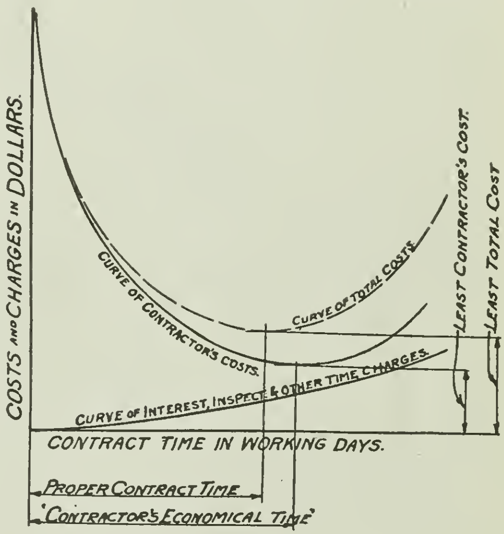

Fig. 1.

bidders desire, is quite clear to those who have studied prices bid when work was scarce and when therefore most, if not all, of the bidders were competing keenly for the job.

Also, that there is ample room for considerable differences between even the most carefully estimated contractor's costs and the actual contractor's costs is quite evident to those who have first planned and estimated and later built and operated contractor's plants.

In view, therefore, of the large number of assumptions which must be made and of the immense amount of work involved in creating such a "rope of sand" this seemingly more mathematical first method has been discarded in favor of the second method.

As an illustration of this method, the following set of rules, prepared by the author at the suggestion and under the direction of Mr. R. H. Gillespie, chief engineer of sewers and highways, for the use of the engineers of the Bureau of Highways in the Borough of The Bronx, New York City, in the determination of the contract time for regulating and grading are here introduced, the data

for which was furnished by the records of this bureau and the judgments as to which contracts had been prosecuted properly by the engineers thereof.

The Determination of Contract Time.—To determine the number of days which shall be written into any contract for regulating and grading as the number of working days to be allowed under that contract the curves hereto attached are to be used in accordance with the rules herein given.

Explanation.—The work to be done will consist of items of rock or earth excavation or of filling or of both, of curb, of flagging, and of bridge-stones. These may

The main items are liable to be earth and rock excavation or filling. The preliminary parts of items: The excavation of sufficient earth to permit earth and rock excavation to progress simultaneously; the building of sufficient of the pipe drains, inlets, manholes or basins to permit such building and the filling to progress simultaneously or the building of sufficient walls, in those few cases where such wall is necessary before any filling can be done, to permit such wall building and filling to progress simultaneously. The subsequent parts of items: Special structures which can not be completed until after the main item is completed; curb, flagging or bridgestone.

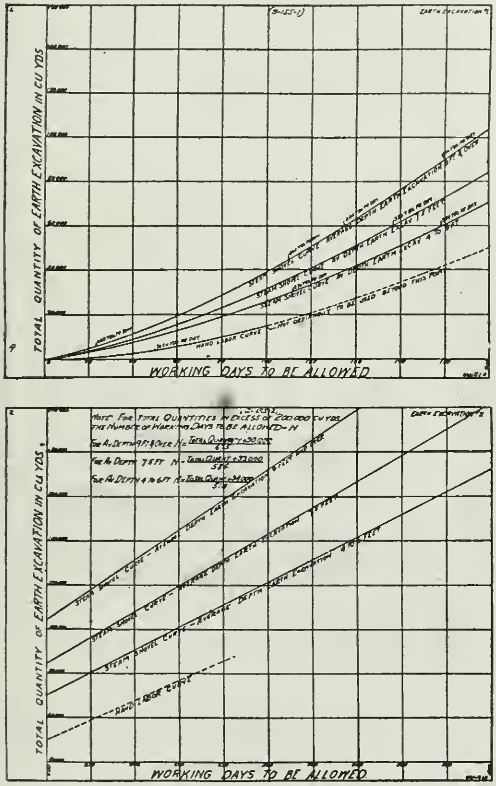

Fig. 2.—Curves for Earth Excavation.

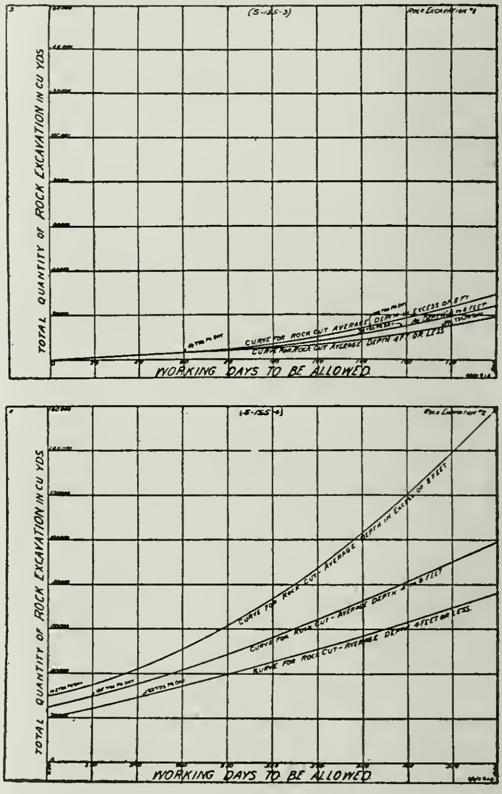

Fig. 3.—Curves for Rock Excavation.

or may not be accompanied by walls of dry rubble, rubble in mortar, or concrete; by pipe drains; by inlets; by receiving basins; by manholes; by piles; and by special constructions.

Items Which Govern.—Ordinarily, work on more than one of these items can be prosecuted at the same time. Care is therefore required to so use the information available of the special conditions surrounding a proposed work, as to eliminate from consideration all of those items and all parts of items which can properly be done during the progress of some other item. There will thus be left as the determining factor in the required time for such work, one, or more rarely, two main items which cannot be done simultaneously and some preliminary and subsequent parts of items.

The curves have been drawn to recognize, in view of the total quantity of an item to be done, the equipment and force which should be used.

They show, accordingly each for its condition, the amount of time for any total quantity which should be consumed in completing that quantity.

Rule "A."—If the time for a part of an item has to be estimated, it is to be taken therefore at the same rate of accomplishment per day as is the total quantity.

Rule "B."—Where conditions are clearly intermediate between those shown by the curves, interpolation is permissible, but where doubt exists, it is preferable as making for lower costs to take that nearest diagrammed condition which gives the longer contract time.

Rule "C."—Where a part of an item comes clearly under one condition recognized in the curves and the remainder as clearly under another, unless the equipment and force which should properly be used for doing these two parts is widely different, the time for the two parts, each taken at the same rate of accomplishment as if the total quantity came under that part's condition, shall be summed to give the time for that item.

Rule "D."—If the equipment, etc., should properly be different, the time for each part of the item is to be taken as if the quantity for this part item were a total quantity and the times so obtained, summed to give the total time for the item.

NOTE.—It is to be remembered that the contract provides that allowances of time for delays occasioned by the weather, or by any act or omission on the city's part, are to be made in addition to the number of working days; and that, therefore, no consideration need be given in this determination to any conditions arising from such causes.

The curves represent average good practice as determined from the records of many contracts done under this office. They do not represent the greatest progress which can be made under good management, and if, therefore, conditions arise not provided for in these curves, such as inability to attack the work in more than a few points, unless the condition is very severe, no additional working days are to be allowed as a total.

Rule "E."—For time necessary to get the work started after being ordered ahead and for stopping, after completion, 10 working days are to be allowed as a total.

Example 1.—On a contract with a centre line length of 8,900 ft. and a street width of 100 ft., there are the following items and quantities:

Earth excavation	88,000	cu. yd.
Rock excavation	26,700	" "
Fill	151,100	" "
Dry rubble masonry	700	" "
Rubble in mortar	25	" "
12-in. pipe	100	lin. ft.
18-in. pipe	575	" "
Manholes	4	
Guard rail	5,800	" "
Lumber	7,500	ft. (B.M.)

No bluestone.

Of the above items, only the earth, and rock excavation and the filling need be considered.

Filling.—It is known that over a portion of the work where filling is required that the street is located on a swamp where settlement will, in all probability, take place. Assume that this settlement will amount to 30,000 cu. yd. Then the total filling required to complete the work would be 151,100 + 30,000 = 181,100 cu. yd.

The sum of the earth and rock excavation equals 114,700 cu. yd. It should be assumed that the entire excavation is to be applied to making the fill so that the material can at least be considered as easily available. The balance of the material required for filling 66,400 cu. yd. must be obtained from outside sources. It is further known that the swamp section of the street is near tide water where material can be obtained by scows. This material, so obtained, should be classed as material "easily available." Even though the dock or nearest obtainable landing may be at some distance from the street under consideration, and especially in view of the possibility of obtaining and placing this filling during the progress of the grading on other portions of the work, it should be classed as "easily available."

An examination of the filling diagram will therefore indicate that considering 181,100 cu. yd. as "easily available," 332 days should be allowed, and adding to this 10 days for starting and stopping, we have 342 days, or, say, 345 days for the contract time.

Excavation.—If, on the other hand, we consider the excavation and know that the earth cutting averages from 4 to 6 ft. in depth, and the rock 4 to 8 ft. in depth, and that 10,000 cu. yd. of earth must be excavated before rock excavation can begin, and that thereafter both will be

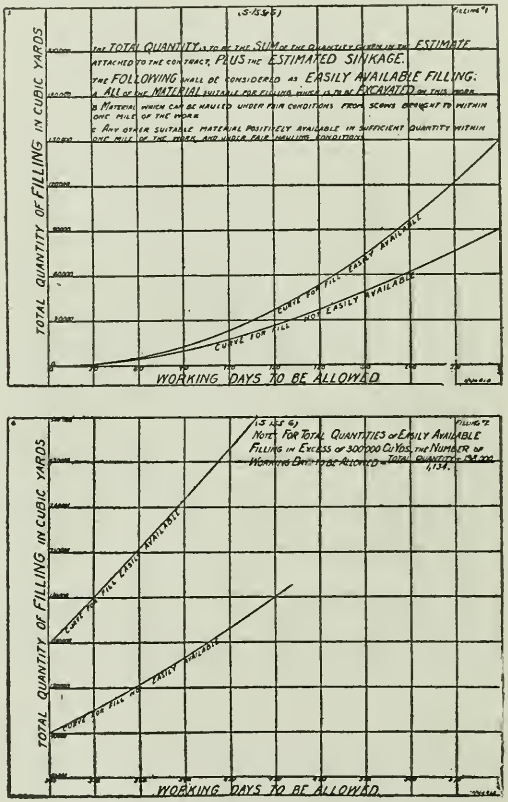

Fig. 4.—Curves for Filling.

carried on simultaneously, we will obtain from the curves the following:

10,000 cu. yd. earth excavation (at 88,000 rate)..	27 days
26,700 cu. yd. rock excavation	212 "
	239 days
Starting and stopping	10 "
	249 days

If we consider only the earth excavation, and assume that while same is in progress the rock will be excavated, we have from curves the following:

88,000 cu. yd. earth excavation	235 days
Starting and stopping	10 "
	245 days

It is evident from the above that the filling required on the work controls and that the contract time should be fixed at 345 days.

Example 2.—

Earth excavation	1,000 cu. yd.
Rock excavation	500 " "
Filling	120,000 " "

In this example the excavation is plainly not to be considered. The filling, if easily available, will, by the curves, require 268 days. If not easily available, filling will require 357 days.

To either of these 10 days should be added for starting and stopping, making either 278 days which call 280 days, or 367 days which call 370 days.

Example 3.—

Earth excavation	6,000 cu. yd.
Rock excavation	6,000 " "
Filling	12,000 " "

If earth overlays rock, the quantity of earth which must be removed to permit rock and earth excavation to progress simultaneously, must be determined from a knowledge of the local conditions. If these conditions

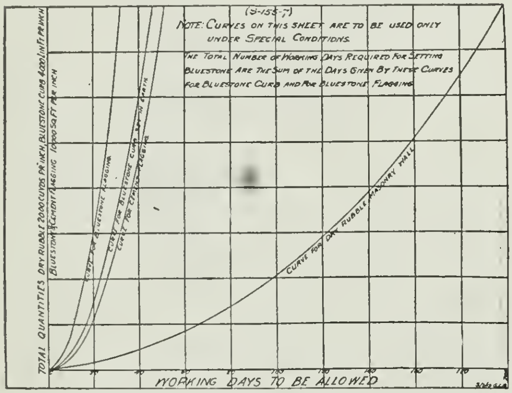

Fig. 5.—Curves for Flagging, Curb and Dry Wall.

show that, say, 35% of the earth has to be removed before the rock excavation can be properly commenced, and that the rock has an average depth of 4 ft. or less, the times required for excavation will be:

For earth 35% of the 64 days required by curve for hand labor for 6,000 yds.

For rock 114 days required by curve for 6,000 yd. of average depth 4 ft. or less.

The sum of these two, plus 10 days for starting and stopping, equals 146 days which call 150 days.

The filling, which is all easily available, would only require 90 days.

Therefore, the contract time for this job would be 150 days.

If earth and rock are in separate cuts and separately approachable so that the two sorts of excavation can properly progress simultaneously, the earth excavation need not be considered. The filling will, of course, not be the determining factor and the rock excavation will be. Under these conditions, the contract time should be for rock excavation, 114 days plus 10 days for starting and stopping equals 124 days, say, 125 days.

Example 4.—

Earth excavation	20,000 cu. yd.
Rock excavation	2,000 " "
Filling	3,000 " "

In this case, the earth overlies subgrade rock throughout most of the work.

The rock excavation remaining to be finished after the earth excavation is completed will amount to about 18% of the total rock excavation.

The filling will not determine the required time.

The earth excavation, being all in shallow cut, will be taken out by hand labor, thus requiring 118 days.

The 2,000 yd. rock, 4 ft. cut or less, would require 36 days, and 18% of this would require 6 days.

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The sum of the above plus 10 days start and stop equals 134 days which call 135 days.

Example 5.—

Earth excavation	1,000 cu. yd.
Rock excavation	6,000 " "
Filling	7,500 " "

Here, the 1,000 cu. yd. earth overlies the 6,000 cu. yd. rock and the conditions show that only a very little earth will be taken off, say, 200 yd., before the rock is commenced. Two hundred yards earth should require about one-fifth of the 24 days required by hand labor curve for the total 1,000 yd., say, 5 days.

Six thousand cubic yards rock, of a 4-ft. or less depth of cut, requires by the curve 114 days.

The sum of the above plus 10 days for start and stopping, equals 129 days which call 130 days, contract time.

Example 6.—

Earth excavation	30,000 cu. yd.
Rock excavation	45,000 " "
Filling (easily available)	120,000 " "

The filling will require by the curve 268 days.

The earth and rock excavation are such that they can be prosecuted quite simultaneously. The rock excavation will therefore control and has an average depth of 6 ft., requiring by the curve 270 days, so that 270 days is good for either.

Therefore, 270 plus 10 days stop and start gives 280 days as the contract time.

Example 7.—

Earth excavation	500 cu. yd.
Bluestone curb	15,000 lin. ft.
Cement flagging	60,000 sq. ft.

As cement flagging and bluestone work can progress simultaneously, the time required will be that for the longer of the two items.

The bluestone curb will, by the curve, require 32 days; the cement flagging 45 days.

Therefore, the cement flagging controls and the contract time should be 45 days plus 10 days start and stop = 55 days.

The application of this method to others of the more usual types of municipal work is obvious and in some cases is under way.

The confidence of contractors in general in the absolute fairness and in the knowledge of the engineer, will, perhaps as much as any other factor, tend to lower the costs of work to be done. And to this end a uniform method of figuring the contract time rather than guessing at it, will, it is believed, contribute in no small degree.

Editorial

ENGINEERING, A VEHICLE OF PRODUCTION.

Although there is no distinct mark of division, one is often led to believe that the relation between science and engineering should be better defined. At any rate, the engineer who recognizes that there exists a line of demarcation, however faint it may be, is less liable to enter upon schemes of an impracticable and therefore wasteful character.

It is perfectly true that the scientist and the engineer are engaged alike in a study of the forces of nature and of ways and means to properly guide and control these forces, so that they may be rendered more serviceable to mankind. But the work of the scientist precedes engineering. It leads him into new and unexplored fields and his investigation reveals the suitability of those fields for exploitation and development. Such is the work of the purely scientific man. It is a noble work; one that has rendered to the race the promotion of the new learning that has been behind the advancement of modern times. Nevertheless, it is perspective, in nature, and must, upon its conception, pass the muster of a combination of engineering and business ability before being presented to the world for assimilation and use. In other words, the purely scientific man must relinquish his conquest to the engineer and the financier in order that it may be judged productive and worthy of development. It is here that the engineer takes hold of the problem. Not previously, or he is encroaching upon the field of the scientist and hazarding his reputation as a reliable engineer.

The situation and its dangers were well protrayed editorially in a recent issue of Engineering (London), while on the subject of the business aspect of the profession. Here it was stated, "It cannot be denied that many engineers are inclined to become too much absorbed in the purely technical aspect of engineering, and to regard their profession a little too much from a standpoint which, though perfectly legitimate in the case of a physicist, is improper in the case of men whose labors are expected to contribute directly and immediately to the wealth of the world. An engineer—and examples are not uncommon—who interests himself solely in the scientific aspect of his profession undoubtedly greatly reduces his opportunities of benefiting his kind, and often is indirectly responsible for much wasteful expenditure. The complaint, for instance, is often made that funds appear to be easily found for the financing of engineering schemes of the most impossible and impracticable character, whilst really reasonable schemes go begging. Were those responsible for the latter better acquainted with the ways of business men, there would be a fair chance of diverting into productive channels resources which are now just as absolutely wasted as if they were invested in a timber yard and immediately fired."

THE TORONTO-HAMILTON HIGHWAY.

Ontario has now entered upon an excellent movement for better roads—one that seems to have the approval of the various classes of road users throughout the province. The appointment last July of the Good Roads and Public Highways Commission was followed by prompt activity resulting in the publication a few months ago of a comprehensive and valuable report. It is most encouraging that the government has seen fit to follow up the suggestions of the Commission, and to adopt its important proposals.

An important line of investigation recommended by the Commission, and one that has already been entered upon, is a motor survey of the main travelled roads in order to acquire an estimate of their present state and of the nature and amount of work necessary to bring them up to the required standard. Chief among the roads now being subjected to the motor survey and traffic census is the Lake Shore road between Toronto and Hamilton. Fourteen men were detailed for this work last week. It is perhaps the most important road falling in the interurban class, and it is one most in need of immediate attention. There are three roads under the travel of the Toronto-Hamilton traffic (including that to and from a number of intervening points) and none of them is in anything like a satisfactory condition. It is the desire of the Commission to construct a permanent road, with concrete base, 20 feet in width. The expense will be borne jointly by the province, the urban termini, the towns en route and the counties through which it passes.

There is every probability that the present investigation will be followed by early construction. The materialization of a thoroughfare commensurate with the importance of the route, its commercial and pleasure traffic, and its scenic possibilities will be a most praiseworthy achievement on the part of the Commission, and a work that will render easier the conception of similar highway enterprises in other parts of the province. Undoubtedly the successful carrying out of this 35-mile piece of permanent road by the Commission will have a farther reaching effect on the good roads movement that has swept the Dominion than one is led to believe from a mere consideration of the benefits that will accrue to the local municipalities.

NOVEL METHOD OF ADJUSTING CROSS-HAIRS.

A novel method of adjusting cross-hairs is described by a recent contributor to a mining contemporary, and shows one of the ways in which tedious and costly delays may sometimes be avoided in survey work. Breakages of cross-hairs in a transit are not common in instruments fitted with finely drawn metalic cross-hairs, but there are sets in use made of spider webs which are apt to give trouble with the slightest provocation. While new webs may conveniently be found, a means of cementing them in position is not always available. The writer found himself with a broken set of cross-hairs when far from headquarters and without any suitable means of adjusting new ones. The circumstances necessitated emergency measures and as an experiment new webs were fastened in place with the membrane next to the shell of a bird's egg, the desired tension being given to the web with the fingers, a pair of dividers being unavailable.

After six weeks of hard service the transit was sent to the repair factory for general repairs and the spider webs were found in good shape.

STEAM TRACTOR vs. TEAM LABOR IN THE HAULAGE OF ROAD MATERIAL.

THE advantages of steam tractor haulage over team labor in road work is the subject of a useful paper that was read on June 6th, 1914, at a meeting of the Institution of Municipal and County Engineers by Mr. W. L. Gibson, one of the road surveyors of Perthshire County. The paper presented some detailed statements of working expenses of tractors, and comparisons of cost of team labor. Several are given as examples of a year's work, and the method of keeping the cost, while others show abstracts and analyses of the whole time during which the tractors had been at work. A portion of Mr. Gibson's paper is given below:—

No small debt is due to the efforts of the makers of road plant in having contributed to the great advance made in modern times in the methods of road-making and maintenance, and not least in the manufacture and transportation of all kinds of material necessary for road work. The ratepayers, no less than road surveyors, owe them a debt for carrying out the great work at the minimum of cost.

Within the last thirty years the methods of road construction and maintenance have been revolutionized. For generations, we may say, no advance was made on the methods taught by the Romans. Insufficient attention was paid to the importance of good roads, and up to a generation ago the work was carried out by rule-of-thumb methods by the local blacksmith, who supplied the plant, consisting chiefly of tools, and the farmer and the local carting contractor who did the haulage.

Under this primitive system of haulage most of the material had to be distributed into depots along the roadside, entailing extra expenditure in relifting while road-surfacing, and often there was difficulty in securing the necessary amount of team labor when required in isolated districts. But now road-making has been elevated from the position of mere empiric practice to the dignity of a science. The local blacksmith, the farmer, and the local carting contractor are being replaced by engineering experts, who undertake the supply of all kinds of plant necessary for the most improved methods of road-making and maintenance and haulage of material.

In no department is the advance more notable than in the substitution of mechanically propelled vehicles for team labor. It is the purpose of this paper to consider some of the advantages possessed by tractor haulage as compared with team labor, and to present observations which may be useful to road engineers and surveyors who contemplate the adoption of the more modern method. The writer was the first county road surveyor in Scotland to adopt tractor haulage, and having now had ten years' experience of this method of transportation is in a position to submit some observations on the subject, accompanied by detailed statements of actual cost and comparative analyses of tractor haulage as compared with team labor.

It has been said that "the bigger the load the cheaper the cost per ton-mile." If this be true, haulage by heavy traction engines is still the cheapest known method of road transport, so far as cost per ton-mile is concerned. Nevertheless, road surveyors must consider the question of damage to road by such haulage, and it is, therefore, necessary for them to keep the axle weights within reasonable limits. If heavy plant is used surveyors must make and maintain their roads to meet this class of traffic, which means that a large initial expenditure as well as a large annual cost would be required to meet the expense of road maintenance for their own traffic. If, on the other hand, light tractor haulage be employed there is a marked saving in the wear and tear to the road surface as contrasted with the heavier plant. We must, therefore, qualify our axiom that "the bigger the load the cheaper the cost per ton-mile" by this rider, "The heavier the axle weight the greater the damage to roads," with its corollary of increased cost for maintenance.

To secure at one and the same time cheapness of transport and minimum damage to roads must be the aim and ideal of the skilful road engineer, and it is my opinion that the two aims are irreconcilable so long as heavy traction haulage is employed. On other grounds the use of heavy traction haulage is to be deprecated.

The question of easy working—i.e., turning and shunting on narrow roads, and in quarries and loading banks of railway sidings—is an important consideration, for it must be remembered that in haulage of road material the primary object is to ply between the quarry or the railway siding and the scene of steam road-rolling operations without the intervention of roadside storing depots, and the inevitable and unnecessary cost of depositing and relifting the material.

Let us consider briefly team labor as regards cheapness of transport and damage to roads.

As far as the first is concerned, team labor cannot compete with tractor haulage. But the difference in wear and tear between light tractor haulage and team labor is a more problematical question, though my own experience goes to confirm me in the view that in some cases —if not in most—there is a difference here also in favor of the former. Indeed, I would go further and affirm that in some cases where the effect of the use of team labor was to cut through the surface and cause deep ruts, the substitution of tractors resulted merely in a depression, which was more easily remedied by making up with metal, and that continued use of the tractor and wagon over the metal in the course of haulage actually producing a much stronger road than before. It is naturally to the advantage of the carting contractor when hauling under contract, to load to the full, but the greater the profit the greater the damage to the road. Here, again, though, of course, in a much less degree, the two aims of the road surveyor cannot be fully secured by the employment of team labor.

In considering as to the adoption of mechanical haulage for West Perthshire, the author recognized that many of the roads were lightly constructed and narrow, and the quarries restricted in area and not easy of access. To adopt heavy traction engines would be almost impracticable for the work contemplated. Under the heavy motor-car regulations the use of self-contained vehicles, such as steam and petrol wagons is permitted; but from the author's point of view they have the disadvantage of the great axle weight on the hind wheels, which are, as a rule, in the case of the steam wagon, only about 3 ft. 6 in. diameter by 10 in. wide, carrying a legal weight—often, unfortunately, exceeded—of 8 tons.

This is quite an extravagant load for an ordinary country road. This type of vehicle has also another disadvantage to road authorities, in that the whole plant must remain idle while being loaded, whereas the tractor, using two tipping wagons, can be hauling the one while the other is loading. The output of this plant, therefore, is greater than that of a steam or petrol wagon, and the produce of the breaker, or tar-macadam mixer, or material from the railway siding, is delivered on the road in a more regular manner. While the higher speed of motor wagons on rubber tires may be considered an advantage for this type, in the present state of develop-

ment of mechanical haulage, it appears that the cost of rubber tires alone, which could be calculated at not less than 4 cents per vehicle mile, and the cost of petrol where motor engines are used, make it impossible for this type to be compared with tractor haulage for the conveyance of road material, irrespective of the disadvantages already mentioned of the self-contained unit.

Notwithstanding rubber tires, the axle weight of this self-contained vehicle has proved to be very damaging to road surfaces where regular services of motor buses, heavy vans, etc., are in operation. It must, of course, be understood that where the roads are strong and smooth, and where facilities are provided for quick and cheap loading, the use of the fast-running motor wagon—either steam or petrol—may be seriously considered; but the author has yet to learn of instances in any way similar to his own work where this type of vehicle has been used at a cost which can be compared with his own experience.

The following points may be suggested for the consideration of road engineers and surveyors who may be contemplating the adoption of mechanical haulage:—

(1) Whether capable of carrying the maximum axle weight of the type of vehicle it is proposed to use.

(2) If the tonnage is small, or the distances unduly short, hire may be cheaper than purchase.

(3) There are still some districts where the prices of cartage are so cheap that purchase of plant may not at present be justified.

(4) Whether the work of the district suits the use of convertible tractor and roller. (The author finds the convertible tractor the most useful plant he has.)

(5) Whether the engine can be utilized for driving small stone-breaker for tar-macadam mixer, supplying steam for rock-drilling, pumping water out of quarries, removing accumulations of road scrapings, hauling tar-sprayers and boilers, or any of the many operations for which a surveyor requires power of any kind.

An analysis of Mr. Gibson's statement of expense for one of the tractors (3 tons) is given in Table I.

Table I.

No. of days hauling	239
Material hauled	5,357 tons
Material hauled per day	22.4 tons
Total distance travelled in 239 days	4,873 miles
Average distance travelled per day	20.4 miles
*Average cost per day	$6.25
Average cost per ton per mile	11.8 cents
Fuel consumed per day	3 cwts.

* This includes filling wagons, time of driver washing out boiler, cleaning, and repairs, with depreciation, etc., estimated at the rate of 22 per cent.

		In percentages.
Cost of carting by team labor	$3,191.13	100
Cost of steam tractor haulage	1,470.07	46
Total saving†	$1,721.06	54

† In addition, the tractor (after 8½ years' work) was sold for $720.00.

Another statement, covering a period of 8½ years, gives, as actual cost of this steam tractor haulage, $10,048.65, with an estimated cost of team labor, amounting to $21,495.00. Concerning another 5-ton tractor, convertible to a 7-ton roller, the figures given in Table II. apply.

Table II.

No. of days' hauling	142
Quantity of material hauled	3,158 tons
Average quantity hauled per day	22.23 tons
Average distance travelled per day	21.95 miles
Total distance travelled in 142 days	3,118 miles
Average cost per day, including filling into wagons and time of driver, washing out boiler, cleaning and repairing (Depreciation and tear and wear included at the rate of 15 per cent.)	$5.80
Average cost per ton mile	10.28 cents
Fuel consumed per day	3 cwt.

		In percentages.
Cost of carting by old contract system	$1,978.04	100.0
Cost of motor haulage	821.86	40.8
Total saving	$1,156.18	59.2

Note.—This tractor, being convertible to a 7-ton road roller, was engaged at rolling operations for 141 days at an average cost of $4.58 per day.

This tractor, during a period of six years, effected a saving of over $4,644.00, allowing for depreciation at the rate of 15 per cent. per annum, when compared with the estimated cost of team labor over that period.

ONTARIO ROAD SURVEY.

Motor surveys of the 18 Ontario counties where highway systems have not yet been organized, have been commenced under the auspices of the Good Roads Commission and directed by W. A. Maclean, Provincial Highways Engineer. Three parties will go north, east and west; and the fourth will cover the central district. The work is to be handled by trained engineers and surveyors. The first group will cover Ontario, Victoria, Peterboro, Northumberland and Durham; the second, Essex, Kent, Elgin and Lambton; the third, Bruce, Huron, Grey and Dufferin; the fourth, Dundas, Stormont, Glengarry, Prescott and Russell. A report will be made to the Government as to the best method of making the various township routes co-ordinate with the county market roads. The market and shipping points in all the counties will be ascertained as well as the population, the volume of traffic on the roads, the location of building materials, and the estimated cost of construction.

The department has plans of every township in the province in preparation, and these will be used in an effort to systematize the roadway system throughout Ontario.

The report of the chief of the Vancouver, B.C., fire department shows that its equipment consists of 18 pieces of automobile apparatus—two ladder trucks, eight hose wagons, one combination hose and chemical wagon, five chemical engines, one chief's car, and one assistant-chief's car; one self-propelled steam fire engine, 14 horse-drawn apparatus—four steam engines, two ladder trucks, five hose wagons, one combination hose and chemical wagon, and two chemical engines; and 31 horses. Owing to the city's recent rapid growth, it has been enabled in purchasing to secure apparatus of the latest improved makes, and in consequence has an excellent equipment for a city of its size and population. The first automobile apparatus was purchased in 1908, and since that time whenever old apparatus was replaced or the demands of the city required increased equipment, this class of apparatus has been added.

DESIGN OF STEEL TURNTABLE.

It is only when one attempts to find some data on the subject of turntables and their design that he discovers the lack of material on this phase of structural engineering. Text books practically ignore the subject, and data in the engineering periodicals is correspondingly scarce.

In *The Canadian Engineer* for November 21st, 1912, an article appeared dealing with the design of turntables for heavy locomotives. Some years previous the "American Engineer and Railway Review" published an article, written by a Mr. Greenleaf, a designer and builder of bridges. Later the "Engineering Record" contained in its columns an article chiefly commentary on the lack of knowledge on the subject. The latest information to appear respecting the design of turntables in that contributed by E. C. White, C.E., to the "Cornell Civil Engineer." Mr. White is an instructor of civil engineering at Cornell University. The following is from his treatment of the subject:

The early turntables were made of wood, and in general were quite unsatisfactory. Cast iron was later substituted for wood. The cast iron turntables were made in two pieces which were tied together by strips of iron set into the top. These were in turn replaced by the modern steel structure, thus keeping pace with the development on structural design. It is in the treatment of the modern steel turntable that data is so scarce. Practically the only data on the subject that was of any use to the author in making his design, outside of ordinary mechanics, was a stress diagram shown in "American Engineering and Railway Review."

The size and length of turntable to be used is governed by the maximum weight and length of the engines now used, with proper allowance for probable future increase. An ample length at the present time is 75 feet to 100 feet; but few of the longer types are now in use. The tendency, however, is toward gradual increase in size and length of locomotive, necessitating longer and heavier turntables.

The locomotive turntable may be said to be a swing bridge on a centre bearing. The bearing may be a nest of rollers, ball bearings, or a bronze disc. The design here shown is of the latter type, with Cooper's Class E 55 live loading. The design is quite similar to that of a plate girder with somewhat varying kinds of stresses depending on the position of the live load upon the structure. Under dead load and under balanced live load stresses the girders act as two cantilevers joined at the centre. When the load is moving onto the structure it may be treated as a continuous beam on two supports, or to produce the greatest stresses, as a simple beam from end to centre supports. In a full determination of the stresses the effect of the engine coming onto the structure must be considered. As an example, if an engine with trucks is considered, the stress will be found to be less than that produced by a switching engine as it comes on. Thus the stresses under this condition of loading, i.e., to produce the worst possible conditions, should be taken under wheel two. The results of these investigations are shown on the stress diagram in Fig. 1. The position of the wheels in the plate apply to the moment or stress diagram under the balanced condition, and also to the shear diagram under the same condition of loading. It will be noticed that under a balanced load for this type of loading the

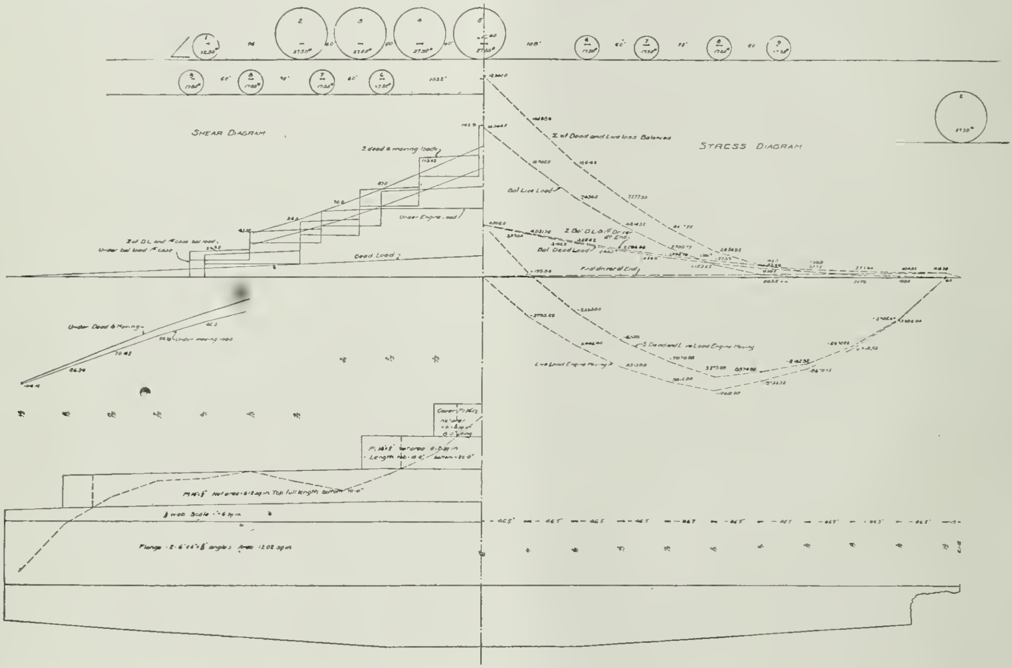


Fig. 1.—Shear and Stress Diagrams.

tender produces maximum stress. Also maximum stress is caused by both engine and tender, and in places, by moving load. The lower part of this plate shows flange

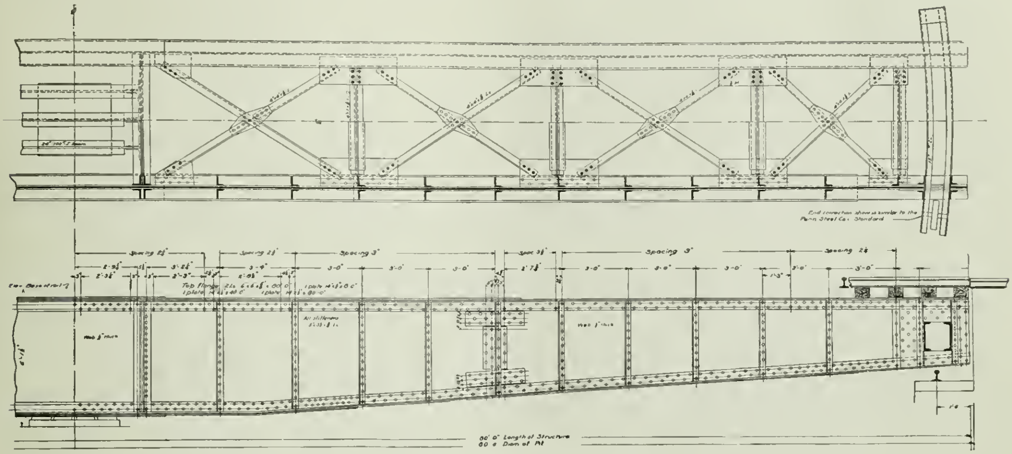


Fig. 2.—Details of Steel Turntable.

area required from point to point, and the make-up of the section used.

Having found the stresses and shear values, the next step in the design is the same as for a plate girder. As no impact is allowed except at the ends (where it was taken as 100%) the unit shearing stress used was 6,000 pounds per square inch, and a unit tension and compression of 10,000 pounds per square inch. The details are

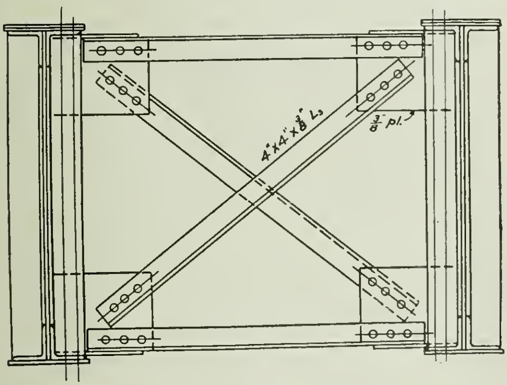


Fig. 3.—Lateral System.

shown in Fig. 2. The lateral stresses are indeterminate and angles are used according to standard practice, in plate girder design, with full section developed at all joints or plates. The details of the lateral system, are shown in Fig. 3. Fig. 4 shows a section through the bronze disc centre bearing.

The assumed dead load was taken as that given by the formula ($w = 10\ l + 100$) for a deck plate girder, using one-half the length of turntable as l. This value

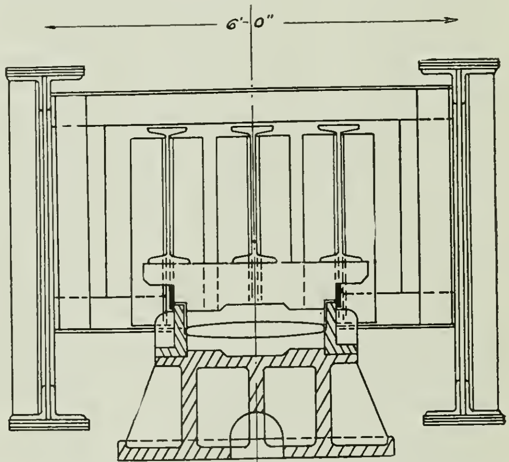


Fig. 4.—Section Through Bronze Disc, Centre Bearing.

checked slightly over the actual computed weight of the completed design, the difference being insufficient to affect the design.

Recently the City Council of Toronto unanimously adopted a minimum rate of wages of 25 cents per hour, for all organizations engaged upon civic contracts. The recommendation involves the recognition of a higher standard of wage for workmen engaged by the city. The present minimum rate of 18 cents per hour was established many years ago, since which time the cost of living has increased continuously from year to year.

Within a range of 10 miles of Lethbridge, a discovery of mica, which is stated to be almost pure, has been made by L. P. Tuff, a prospector, formerly of Montana. In some instances, the samples shown are several inches thick, and are perfect in cleavage. Specimens have been sent to the Ottawa Government for examination. Mr. Tuff is also of the opinion that silica sand also exists in the neighborhood of the mica formation.

DERIVATION OF RUN-OFF FROM RAINFALL DATA IN WATER SUPPLY AND WATER POWER PROJECTS.

HYDRAULIC, municipal, and consulting engineers fully comprehend the importance of run-off data in the study of water power or water supply propositions. Of particular interest to them is a paper on the subject by Mr. J. D. Justin, principal assistant engineer, Board of Public Works, Harrisburg, Pa., read last year before the American Society of Civil Engineers and published in the proceedings for August. It deals with a series of experiments undertaken by him to solve a method of deriving run-off from the rainfall data of a drainage basin. Mr. Justin's paper is, in part, as follows:

The quantity of rainfall appearing as run-off on any watershed is governed by many conditions, chief among which are character of vegetation, extent of forest covering, prevailing winds, relative humidity of atmosphere, barometric pressure, percentage of water surface, geology of basin, slope, and mean annual temperature. Before investigating the manner in which the relations between rainfall and run-off differ on various watersheds the writer will consider the manner in which they vary from year to year on any one watershed.

George W. Rafter showed that the relation of rainfall to run-off on a watershed could often be expressed as an exponential equation. For the upper Hudson he gives the two equations $P^2 = 84.5\ R$ and $P^{1.77} = 34.3\ R$; P being the annual precipitation and R the annual run-off, in inches, on the watershed. He does not, however, suggest any constant value for the exponent of P or R for other watersheds.

After plotting many rainfall and run-off data, the writer became convinced that the relations between rainfall and run-off on almost every watershed could be expressed by a logarithmic equation, of the form, $C = K\ R^n$, in which C = annual run-off, R = annual rainfall, K is an abstract number, constant for any one watershed, and n is an exponent constant for the watershed.

In solving the equations it was found that n always came out nearly equal to 2; hence it was chosen as a constant for all watersheds and always equal to 2.

The writer then plotted, on logarithmic cross-section paper, using annual run-off in inches as ordinates and annual rainfall in inches as abscissas, a considerable portion of the available reliable data. He found that on all these watersheds the relation may be well expressed by the formula:

$$C = KR^2,$$

in which C is the annual run-off in inches; R is the annual rainfall in inches, and K is a constant which is different for each watershed and has a value depending on those conditions which make the relations between rainfall and run-off on one watershed different from those on another.

Mr. Justin presents 19 diagrams in his paper to show the relation of rainfall to run-off. As stated above, the graph showing this relation is plotted on logarithmic paper and is, therefore, a straight line. The run-off C in inches is plotted as ordinates, and the rainfall R in inches as ordinates on each diagram. Table 1. has been prepared from these 19 diagrams. It gives the name of the watershed, area of watershed, locality for which the relation between rainfall and run-off is expressed, and the value of the coefficient K in the formula $C = KR^2$.

Accuracy of Data.—The accuracy of existing data does not justify precision. On some of the territories for which diagrams were prepared there is one rainfall station per 1,000 sq. miles of watershed. In the computation of run-off a discrepancy of 1 or 2 ins. is not worthy of discussion. In most cases one can safely assume a probable error of 10 per cent. in the observed rainfall for any one year for most watersheds. The error in any individual record at a certain station is undoubtedly less than this in most cases, but when several rainfall stations are combined to give the rainfall for an entire watershed the probable error is increased. In general, the larger the number of rainfall stations on a watershed the less the probable error.

Run-off records are usually more accurate, but up to a few years ago few streams were accurately gauged, and the error was generally positive. At present many of the records of the water resources branch of the United States Geological Survey and of many municipal water supplies are all that could be desired, the probable error not exceeding 5 per cent. Perhaps one of the most accurate

Table I.—Value of K for 19 Eastern Watersheds.

Name of watershed.	Area of watershed, sq. miles.	Locality.	Value of K.
Esopus Creek	239	Esopus Weir	0.01292
Hudson River	4,500	Mechanicsville	0.0118
Genesee River	1,070	.....	0.00890
Schoharie	240	Prattsville, N.Y.	0.01485
Connecticut River	10,234	Hartford, Conn.	0.0117
Sudbury River	75.2	.....	0.0109
Connecticut River	3,300	above Orford, N.H.	0.016
Ohio River	23,820	above Wheeling, W. Va.	0.0131
Susquehanna River	9,810	above Wilkesbarre, Pa.	0.0149
Tohickon Creek	102.2	.....	0.0115
Perkiomen Creek	152	.....	0.0105
Croton River	338.8	above New Croton Dam	0.0094
Rondout Creek	105	Honk Falls and Lackawack	0.0130
Susquehanna River	28,030	above Harrisburg, Pa.	0.0135
Potomac River	11,043	.....	0.0119
Lake Cochituate	18.9	.....	0.0092
Nashua River	118	Clinton, Mass.	0.0116
Passaic River	822	Dundee Dam	0.0115
Neshaminy Creek	139.3	.....	0.0099

records for purposes of comparison between rainfall and run-off is that on the Esopus watershed (area 239 sq. miles) of the Catskill water supply system of New York City. On this watershed there have been maintained from 8 to 13 well-distributed rainfall stations. The measurement of run-off has been made at a concrete weir especially built for the purpose.

The relation between rainfall and run-off on this watershed is shown in Table I. All the points in the diagram fell almost precisely on the curve, $C=0.01292R^2$.

When rainfall and run-off data are plotted on diagrams the probable error in using the resulting curves in mass curve storage studies is much reduced.

Effect of Proportion of Water Surface.—The writer believes that many hydrologists have exaggerated the importance of the effect of water surfaces on a watershed in decreasing the quantity of run-off. Aside from regulating the distribution of the run-off throughout the year, the effect of any ordinary proportion of water surface is so small as to be negligible.

This is well shown by Mr. Rafter. In discussing the percentage of water surface on the Croton watershed (3.56 per cent.) he says:

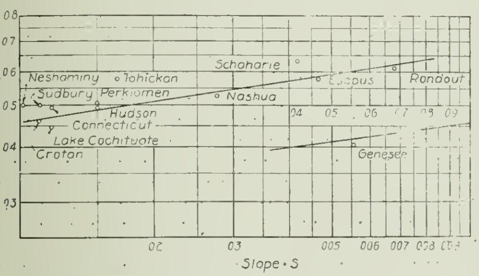


Fig. I.—Diagram Showing Relation Between K, T and S. (K = Const. in Eq.; $C = KR^2$; T = mean annual temp.; S = slope of watershed.)

"It may at first thought be imagined that these large water surfaces exposed to evaporation have considerably increased the ground evaporation over the entire catchment. When, however, one considers that it is only the difference between what a water-surface evaporation and what a ground-surface evaporation would be, the difference is seen to be not very much. For instance, assuming the water-surface evaporation at 36 ins. per year and the ground-surface evaporation at 27 ins. per year, the difference becomes 9 ins. With 12 square miles of water surface in 1900, giving 3.56 per cent. of the whole, the excess of water-surface evaporation over ground-surface evaporation is 0.32 in., a quantity which is so far within the limit of possible error in other directions as to be negligible.

Grouping of Data by Water Years.—In the comparison of rainfall and run-off grouped by water years, beginning October 1, December 1, or some other date, it is frequently observed that on any watershed certain years, having the same recorded rainfall, have recorded run-off differing by from 1 to 4 ins.

In the 19 diagrams, although most of the points fall on or near the curves represented by the equation, $C = KR^2$, there are some which are at some distance from the curves. Noting this condition, many claim it as proof that there is no definite relation between rainfall and run-off. In reality, the apparent discrepancy is due merely to variation from year to year in ground-water conditions on the date arbitrarily assumed for beginning the water year. The fact that a point does not fall on the curves does not necessarily show that the observations are at fault, but in most cases it does indicate that the date of beginning the water year assumed for the watershed is not the true one for that particular year.

It is an error to consider the water year as a hard and fast division of time. Many of the points which in the diagrams plot some distance from that curve would fall directly on or very near it, had the first of the preceding or succeeding month been used for beginning the water year.

The true water year does not begin or end at any particular date, but should be regulated so that ground-water conditions are nearly constant on the dates selected for the beginning of such years. It is believed that if this could be done all points for which the data are accurate would fall on or near the curve represented by the equation, $C = KR^2$.

Owing, however, to the almost utter lack of data on ground-water levels, it is impracticable to adopt this method of division. Especially in the study of large storage propositions the apparent discrepancies will balance each other and will not affect the conclusions.

Table II.—Values of K, T, S, and KT, for Various Watersheds.

Watershed	K—in the formula, $C=KR^2$	T—Mean annual temperature.	S—Slope of watershed.	KT=K×T.
Lake Cochituate	0.0092	48.5	0.0116	0.446
Sudbury	0.0109	46.0	0.0119	0.501
Hudson	0.0118	41.9	0.0149	0.494
Rondout	0.0130	47.0	0.0664	0.611
Croton	0.0094	49.0	0.0110	0.460
Esopus	0.01292	44.5	0.0468	0.575
Passaic	0.0115	48.4	0.00977	0.555
Genesee	0.0089	45.5	0.00554	0.405
Neshaminy	0.0099	50.6	0.0101	0.500
Perkiomen	0.0105	48.6	0.0148	0.511
Tohickon	0.0115	49.6	0.0166	0.571
Nashua	0.0116	45.0	0.0278	0.522
Connecticut	0.0117	42.0	0.0117	0.490
Schoharie	0.01485	42.3	0.0367	0.630

Manner in Which the Relations Between Rainfall and Run-off Vary from One Watershed to Another.—It has frequently been observed that, other things being equal, a steep watershed will have a greater run-off for the same rainfall than a flat one. The water, staying on the watershed a shorter length of time, has less chance to evaporate. Mr. Vermeule has shown successfully the great influence which the mean annual temperature of a watershed has on the relation of rainfall to run-off.

These two elements, slope and mean annual temperature, the writer believes are, in general, the chief factors determining the manner in which the relation between rainfall and run-off vary from one watershed to another. Hence he will use them in determining the value of K.

The slope of a watershed may be defined as the difference in elevation between the highest and lowest points divided by the square root of the area.

The proper value for the mean annual temperature of a watershed can generally be determined by a study of the data published by the United States Weather Bureau in

the "Summary of Climatological Data for the United States by Sections." In using these data it sometimes happens, especially on mountainous watersheds, that all the observations are at stations in the valleys. On such a watershed the mean annual temperature frequently varies directly with the elevation. In such a case a practical method of determining the mean annual temperature would be as follows: (1) Take the average temperature at the stations. (2) The average elevation for the same stations. (3) The average elevation of the watershed = the elevation of the highest point plus the elevation of the lowest, divided by 2. (4) Take the difference between the average elevation of the stations and the average elevation of the watershed. (5) Multiply this by the mean difference in temperature per foot of increase in elevation. (6) Finally, subtracting this from the average temperature at the stations will give the mean annual temperature of the watershed.

In Fig. 1 T is the mean annual temperature; S is the slope of the watershed, determined as previously described, and K is the constant in the equation, $C = K R^2$.

It was found that for several watersheds having about the same value of S, K varied very nearly as the first power of T. In Fig. 1 the values of KT (the product of K and T) have been plotted as ordinates and the values of S as abscissas.

Table II. gives the values of K, T, S, and KT for various watersheds.

Picking values off the logarithmic curve in Fig. 1 and solving the equation,

$$K\,T = P\,S^x,$$

P being the unknown coefficient and x the unknown exponent, we have, for the equation of the curve, $K\,T = 0.934\,S^{0.188}$

$$\text{but } C = K\,R^2,$$

$$\text{whence } C = 0.934\,S^{0.155}\,\frac{R^2}{T}$$

which is the general formula for the relation of run-off to rainfall.

C = Annual run-off, in inches, on the watershed;
R = Annual rainfall, in inches, on the watershed;
S = Slope of the watershed, equals the elevation of the highest point minus the elevation of the lowest point, divided by the square root of the area;
T = Mean annual temperature of the watershed, in degrees, Fahrenheit.

For convenience in using the formula, Table III., giving values of $S^{0.155}$ was computed. By using this table the formula is easily solved. Thus, for the Rondout watershed, $T = 47$, mean $R = 46.6$, and $S = 0.0664$. From Table III. for $S = 0.0664$, we have $S^{0.155} = 0.658$. Hence the expression for the mean annual run-off of the Rondout becomes

$$C = 0.934\,S^{0.155}\,\frac{R^2}{T} = 0.934 \times \frac{0.658 \times 2180}{47} = 28.5 \text{ ins.}$$

In this case the computed mean annual run-off is just equal to the actual.

The character of the various watersheds considered in the derivation of the formula varies widely. By reference to Table II. it is seen that the slope and the mean annual temperature vary between wide limits. The slope of the Genesee is 0.0054, and that of the Rondout is 0.0664. The mean annual temperature of the Hudson is 41.9 and that of the Neshaminy is 50.6 degrees. In area the variation is from 19 sq. miles for the Lake Cochituate watershed to 10,234 sq. miles for the Connecticut at Hartford. In the matter of forestation the variation is also large, from the watershed of the Genesee with its gently rolling farm lands and few woods, to the heavily forested head waters of the Rondout and upper Hudson. The effect of forests on the quantity of rainfall and run-off is believed to be slight, but on the distribution of run-off throughout the year it is very marked. Other things being equal, a watershed which has been denuded of its forest will have a much lower minimum discharge in summer and will be subject to more violent floods in times of high water.

Table IV. is a comparison, for various watersheds, of the run-off computed by the formula and the recorded observed run-off.

It will be noticed that the closest agreement between the computed and the observed run-off is for the water-

Table III.—Values of $S^{0.156}$ for Various Values of S. To be Used in Solving the Formula, $C = 0.934\,S^{0.155}\,\frac{R^2}{T}$.

S.	$S^{0.155}$.	S.	$S^{0.155}$.	S.	$S^{0.155}$.	S.	$S^{0.155}$.	S.	$S^{0.155}$.
0.002	0.382	0.0070	0.464	0.0093	0.484	0.026	0.567	0.049	0.628
0.003	0.406	0.0071	0.465	0.0094	0.484	0.027	0.570	0.050	0.630
0.004	0.425	0.0072	0.466	0.0095	0.485	0.028	0.574	0.051	0.632
0.005	0.440	0.0073	0.467	0.0096	0.486	0.029	0.578	0.052	0.634
0.0051	0.442	0.0074	0.468	0.0097	0.487	0.030	0.582	0.053	0.636
0.0052	0.443	0.0075	0.469	0.0098	0.488	0.031	0.584	0.054	0.638
0.0053	0.444	0.0076	0.470	0.0099	0.489	0.032	0.587	0.055	0.640
0.0054	0.445	0.0077	0.471	0.010	0.490	0.033	0.590	0.056	0.641
0.0055	0.446	0.0078	0.472	0.011	0.496	0.034	0.592	0.057	0.642
0.0056	0.447	0.0079	0.473	0.012	0.502	0.035	0.595	0.058	0.644
0.0057	0.448	0.0080	0.474	0.013	0.509	0.036	0.597	0.059	0.646
0.0058	0.449	0.0081	0.475	0.014	0.514	0.037	0.600	0.060	0.648
0.0059	0.450	0.0082	0.476	0.015	0.520	0.038	0.602	0.061	0.650
0.0060	0.451	0.0083	0.477	0.016	0.526	0.039	0.604	0.062	0.652
0.0061	0.453	0.0084	0.477	0.017	0.531	0.040	0.606	0.063	0.653
0.0062	0.454	0.0085	0.478	0.018	0.536	0.041	0.609	0.064	0.654
0.0063	0.456	0.0086	0.479	0.019	0.541	0.042	0.612	0.065	0.656
0.0064	0.458	0.0087	0.479	0.020	0.545	0.043	0.614	0.066	0.658
0.0065	0.459	0.0088	0.480	0.021	0.549	0.044	0.616	0.067	0.659
0.0066	0.460	0.0089	0.481	0.022	0.552	0.045	0.619	0.068	0.660
0.0067	0.461	0.0090	0.482	0.023	0.556	0.046	0.621	0.069	0.661
0.0068	0.462	0.0091	0.482	0.024	0.560	0.047	0.624	0.070	0.662
0.0069	0.463	0.0002	0.483	0.025	0.563	0.048	0.626		

sheds where the data are the most reliable—for instance, the Hudson, Genesee, Esopus and Croton. Furthermore, where there is any material variation the computed quantities are generally less than the observed. Accordingly, the use of the formula for estimates of flow will be likely to give quantities which are less than the actual, rather than those that are more; that is, the error is on the side of safety.

The formula is also applicable for the computation of run-off for individual years. For illustration, take two watersheds—the Hudson and the Esopus. In the case of the Hudson, $S = 0.0149$ and $T = 41.9$, and the formula becomes

$$C = 0.934 \frac{0.520\ R^2}{41.9},$$

$$\text{or } C = 0.0116\ R^2.$$

In the case of the Esopus, $S = 0.0468$ and $T = 44.5$, and the formula becomes

$$C = 0.934 \frac{0.623\ R^2}{44.5} = 0.0130\ R^2.$$

These two illustrations serve to show the degree of accuracy that may be expected in the use of the formula when the rainfall and temperature data are fairly accurate.

The Supply of Missing Records.—It sometimes happens that only two or three years of good run-off records have been kept on a watershed, and that the rainfall records are available for a number of years. In such a case the record may be extended in the following manner:

Table IV.—Comparison Between Observed Run-off and Run-off Computed by the Formula, $C = 0.934\ S^{0.155} \frac{R^2}{T}$.

Watershed.	Mean annual rainfall observed, in inches.	Mean annual run-off observed, in inches.	Mean annual run-off computed, in inches.	Difference, in inches.
Rondout	46.7	28.5	28.5	0
Sudbury	45.7	23.6	21.3	2.3
Connecticut	43.5	23.8	21.1	2.7
Lake Cochituate	47.3	20.4	21.5	1.1
Esopus	48.3	30.1	30.4	0.3
Nashua	48.7	25.4	28.2	2.8
Tohickon	48.4	26.7	23.5	3.2
Croton	49.3	22.6	23.0	0.4
Perkiomen	47.6	23.6	22.6	1.0
Passaic	46.8	25.3	20.7	4.6
Neshaminy	47.8	22.8	20.7	2.1
Genesee	40.4	14.3	14.9	0.6
Muskingum	42.4	15.1	13.3	1.8
Hudson	44.5	23.5	22.9	0.6

Plot on logarithmic cross-section paper points for the two or three years of known run-off, using rainfall abscissas and run-off as ordinates. Compute the run-off for several other years, using the formula

$$C = 0.934\ S^{0.155} \frac{R^2}{T}.$$

Plot the corresponding points. Then draw a straight line parallel to the line $Y = X^2$, among these points giving greater weight to the observed data. This line will be represented by the equation $C = K\ R^2$. Having this curve, the run-off for any year may be read off, using the rainfall as argument.

Application to the Mass-Curve.—Engineers are frequently called on to construct reservoirs of considerable capacity on watersheds where accurate run-off data are lacking. For the determination of the necessary capacity of a proposed reservoir the mass-curve is the accepted method. Having given a watershed without run-off data, but with rainfall records available, a satisfactory mass-curve may be constructed by using the formula

$$C = 0.934\ S^{0.155} \frac{R^2}{T}.$$

The values of S and T are generally easy of determination for any particular watershed.

In using this formula for the construction of a mass-curve it is applied to the rainfall for each month consecutively, and the resulting monthly run-off is used in constructing the mass-curve in the usual manner. Of course, using the formula in this way, the resulting computed run-off for individual months will often be very different from the actual; but in the study of large water power or water supply projects, where water must be stored for several months, this will not affect the conclusions as to the necessary size of the reservoir for a given draft.

The most expeditious method of applying the formula for this purpose is as follows:

Compute several values of C for given monthly values of R. Plot these computed values of C, with the corresponding values of R, on logarithmic cross-section paper. The points will lie in a straight line. This logarithmic curve may then be used for picking off values of C for given values of R.

Two mass-curves for the Croton watershed were plotted by the author. The upper curve was obtained from the recorded run-off data, and the points on the lower curve were computed by the formula, $C = 0.934\ S^{0.155} \frac{R^2}{T}$. It was noticed that the cumulative totals of the observed run-off for 37 years differs from the computed by about 3 per cent., the computed being less than the observed. A draft on the watershed of 1.65 ins. per month, or 320,000,000 gals. per day, was assumed and applied to the curves. The greatest depletion shown on the curve of observed run-off was 14.2 ins., and the mass-curve of computed run-off showed a depletion of 18 ins., a difference of 21 per cent. This difference, however, is on the safe side. It is customary to build reservoirs with a capacity of from 20 to 30 per cent. in excess of the depletion shown by the mass-curve. Had there been no run-off data in existence on the Croton watershed, a reservoir of sufficient capacity could have been decided on from a study of the computed mass-curve.

In a similar manner, two mass-curves were plotted for the Nashua watershed, one from the observed run-off data and the other from computed run-off data obtained by using the formula. A draft of 1.852 ins. per month, or 125,000,000 gals. per day, was assumed. The greatest depletion on the curve of observed run-off was 10 ins., and on the curve of computed run-off, 12 ins., an error which is again on the safe side.

The mass-curves of observed run-off and of computed run-off were plotted for the Esopus watershed. A draft of 1.825 ins., or 250,000,000 gals. per day, was assumed. For the curve of observed run-off, the greatest depletion was 8.2 ins., and, for the curve of computed run-off, the greatest depletion was 7.5 ins. The difference, 0.7 ins., though not on the safe side, is so small that it could not affect materially the size of the reservoir decided on.

Conclusions.—The writer is not of the opinion that the gauging of streams and the accumulation of run-off data should be abandoned, and the method herein described established in their place. Accurate run-off data are scarce, and engineers need far more. These methods and formulas are applicable to watersheds where run-off data are meager or lacking, and it is believed that they will give more reliable results than those now generally in use.

The formula, $C = 0.934\ S^{0.155}\ \frac{R^2}{T}$, is, the writer believes, applicable to the Eastern United States, and, in general, should give results within 10 per cent. of the true run-off. In applying the formula to other watersheds, the writer would advise caution. Although the formula is believed to be general, it is possible that, if more data were at hand on the relation of run-off to rainfall, the value of the constant (here 0.934) and of the exponent of S (0.155) might vary somewhat in other sections of the country, where there is a marked difference in climatic conditions.

Table V.—Comparison Between Observed and Computed Run-off for Various Years, for the Upper Hudson.

Year ending December 1st.	Rainfall observed, in inches.	Run-off observed, in inches.	Run-off computed by formula, in inches.	Difference, in inches.
1888	43.9	23.6	22.3	1.3
1889	43.0	21.7	21.5	0.2
1890	50.4	28.9	29.5	0.6
1891	43.0	20.6	21.5	0.9
1892	53.9	33.1	33.5	0.4
1893	42.2	21.9	20.8	1.1
1894	42.0	19.4	20.4	1.0
1895	36.7	17.5	15.6	1.9
1896	45.2	23.6	23.7	0.1
1897	46.5	26.2	25.0	1.2
1898	48.5	27.1	27.3	0.2
1899	35.8	19.5	14.9	4.6
1900	45.4	20.7	23.8	3.1
1901	42.6	21.9	21.0	0.9

Of course, if this formula is applied to the rainfall for some particular month it will not give the true run-off. It has been shown, however, that it may be used for obtaining monthly run-off, and that the mass-curve when plotted gives depletions which do not differ materially from those obtained when the observed monthly run-off is used in constructing it.

At first sight, the application of the formula may appear to be complicated, but, by using Table III., which gives the values of $S^{0.155}$, it is simple; and if logarithmic plotting is utilized, as suggested, it becomes merely a matter of reading off the curve.

A recent report from Montreal states that a method of converting titanium ore into high grade steel has been discovered by Dr. G. D. Condle, of Montreal, who has been working on the solution of this process for 5 years. It is stated that a new industrial corporation is being formed with a nominal capital of $25,000,000 to take over the rights and all the interests of the new steel process; and a plant is to be set in operation where high grade steel will be produced and sold at about $100 per ton.

A NOTABLE GATHERING OF ENGINEERING EDUCATORS.

On June 23rd there assembled at Princeton, N.J., a group of some two hundred men upon whom largely depends the character of the engineers of this continent for many years to come. Here, for four days, enjoying the freedom of Princeton University, the Society for the Promotion of Engineering Education conducted its twenty-second annual convention.

The choice of meeting place was most happy. In historic Nassau Hall, named in honor of King William the Third, "a branch of the illustrious House of Nassau," and which opened its doors to students in 1756, the executive offices of the convention were located. Regular sessions were held in the Palmer Physical Laboratory, while the annual dinner took place in the magnificent new Graduate College, situated among green fields, three-quarters of a mile to the south of the main group of buildings.

It was a gathering at once representative and diverse. Engineering professors from Boston to Seattle, from Toronto to Mississippi, participated in the deliberations. Veterans like William Kent and Mansfield Merriman rubbed shoulders with vigorous young enthusiasts like Henry H. Norris, of Cornell; Dugald C. Jackson, of "Tech." and F. L. Bishop, the "Boy Dean" of Pittsburgh. Here, from day to day, was witnessed the graciousness and tact of President Anthony, the versatility and precision of Karapetoff and the power and picturesqueness of Franklin, of Lehigh. Silent, but contributive of weight to the deliberations, were Turneaure, of Wisconsin; Talbot, of Illinois, and Ketchum, of Colorado.

On Tuesday at 2.30 the meeting was formally opened with an address of welcome by John Grier Hibben, president of Princeton University. In a few earnest words he indicated the necessity of engineers being scientific, rather than technical, being searchers for the causes of the facts and not merely for the facts themselves. The engineer cannot afford to be a pragmatist—a judger of things in accordance with the way they turn out—but must know beforehand what the result will be and must be able to satisfy his client that he does know.

The receipt and consideration of reports of committees and a meeting of the delegates of the institutional members constituted the formal business of the first day.

At five o'clock a reception to the delegates was tendered by President and Mrs. Hibben at "Prospect," the official residence of the president.

In the evening an informal "get-together" smoker was held at the Nassau Club, facetiously described by one member as a club for gentlemen and members of the Faculty of Princeton University.

The formal welcome of the State of New Jersey was extended on Wednesday morning by the Hon. Jas. F. Fielder, Governor of the State.

With the exception of the few minutes thus occupied, the forenoon was devoted to a session on College Administration. Two admirable papers were presented on the subject, one on "The Financial Department of a School or University," by Mr. T. H. B. McKnight, treasurer of the Pennsylvania lines west of Pittsburgh, and the other on "The Relation of the Administrative Department to the Teacher," by Dr. C. R. Mann, of the University of Chicago, who has been commissioned by the Carnegie Foundation for the Advancement of Teaching to investigate the courses in engineering colleges for the Joint Committee on Engineering Education. From the character of Dr. Mann's address, some severe strictures

on over-administration may be expected in his report to the Joint Committee. In the report of the Committee on Statistics, the surprising fact was brought out that in thirty-two representative engineering colleges of the United States, the attendance for the session 1913-14 was 8.3 per cent. greater than for 1912-13.

Special attention was given on Wednesday afternoon to the relation of scientific management to education. Professor Hugo Diemer, author of "Factory Organization," presented a paper on "Education in Scientific Management," in which the course instituted by him at the Pennsylvania State College was outlined. A paper by Professor L. M. Passano, of the Massachusetts Institute of Technology severely criticizing certain claims of the advocates of scientific management in the matter of promoting "academic efficiency" was read in abstract. The "scientific manager" would, in Professor Passano's opinion, "like the suburbanite, make two blades of grass grow where only one ought to."

In the evening, an interesting lecture was given on "The Meteor Crater in Arizona," by Dean W. F. Magie, of Princeton University.

Thursday morning opened with fireworks: it was the mathematicians' field day. First, a paper by Professors W. S. Franklin, Barry MacNutt and R. L. Charles on "Practical Mathematics" was presented in characteristic style by Professor Franklin. Professor E. V. Huntington, of Harvard, followed with one on "The Use of the Differential in Calculus." Professor E. R. Hedrick, of the University of Missouri, completed the triology with one on "The Calculus Without Symbols." Correct statements of meaning formed the burden of the discussion—a most animated and entertaining one.

Methods of study next came under consideration and papers were read by Professor W. L. Upson, of Union College, on "The Preceptorial System and Electrical Engineering at Union College," by Professor George L. Sullivan, of the University of Santa Clara, on "Teaching Engineers How to Study," and by Professor W. H. Kennerson, Brown University, on "Giving Instruction in Methods of Study."

The afternoon opened with two papers on courses of instruction—one by Professor A. B. McDaniel, of the University of Illinois, on "Co-ordination in Engineering Instruction," and the other by Professor H. S. Jacoby, of Cornell University, on "A Study of Technical College Catalogues with Respect to Descriptions of Courses of Study and of Instruction." Fundamental pedagogical topics received consideration in papers by Professor C. F. Harding, of Purdue University, on "Grading of Students by Universities vs. Grading of Technical Graduates by Employers," and by Professor A. M. Wilson, University of Cincinnati, on "A Report of Progress in Co-operative Education."

At the annual dinner on Thursday evening, Dean Gardner C. Anthony, president of the society, delivered his presidential address—an eloquent plea for a training of more cultural content and for greater co-ordination between liberal arts and technical studies.

On Friday, the 26th, papers were presented by Professor L. F. Rondinella on "Constructive Drawing in High Schools and Engineering Colleges"; by Professor J. B. Whitehead on "A Department of Engineering at the Johns Hopkins University"; by Professor W. M. Wilson, University of Illinois, on "Proposed Courses in Structural Engineering for Civil Engineering Students," and by Professor Chas. E. Lucke, on "The New Mechanical Engineering Course at Columbia University."

At the final session Dean Anson Marston, of the University of Iowa, was elected president of the society, and Dean F. L. Bishop, of Pittsburgh, secretary for the ensuing year.

In the opinion of those present, the Princeton meeting was the best in the history of the society, and if future conventions keep pace with it, a powerful constructive force in engineering education will thereby be maintained from year to year.

ENGINEERING ACTIVITIES IN HALIFAX, N.S.

FROM an engineering standpoint, the city of Halifax is experiencing considerable activity this season compared with other centres of population throughout the Dominion. The Halifax ocean terminals, the construction and organization of which is under the supervision of Mr. Jas. McGregor, C.E., have exhibited marked progress of late, a large quantity of excavation and filling having been completed. Work has progressed on the bulkhead, which is to extend into the harbor for approximately ¼ of a mile and as far south as the proposed breakwater. The plans, together with the construction work as it is at present, indicate that the completed terminal will be one of the finest in North America.

The city engineer's staff has under construction, or supervision, many new sidewalks, sewers and water extensions. The new terminals create further activity in this department owing to the establishment of grades, street lines, building sites, etc.

The city has just completed a pavement on Cogswell Street, the principal artery leading north from the central portion of the town. Granite block pavement was used. It is the intention of the department to use this material for the construction of pavements on a number of hilly streets at an early date. Of these, Argyle Street, the next street of importance outside of the already paved business streets, will be paved this year. There are nearly 50 concrete sidewalks of varying lengths to be under construction at an early date. A considerable length of sewers, chiefly in the outlying districts, is being laid, and it is expected that the question of a large intercepting trunk sewer with an outlet near the mouth of the north-west arm will be up for consideration at an early date.

The high service reservoir, commenced last year, is nearing completion. It will be a great addition to the water system, especially to the north and higher sections of the city. It is built of reinforced concrete, and is located at an elevation of 247 ft. above mean low tide. Mr. H. W. Johnston, C.E., assistant city engineer, was designing engineer and is superintending its construction.

Building operations are decidedly brisk, the largest building being the new market, Dalhousie University science building, St. Mary's College and St. Matthias' Church.

PROGRESS ON ROADS IN NORTHERN ONTARIO.

Mr. J. F. Whitson, Provincial Road Commissioner of Ontario, states in connection with the work on roads in Northern Ontario now in progress, that new roads are being opened up, and many others completed. The trunk road along the Timiskaming and Northern Ontario Railway is being opened up in sections; and this road is now available for almost all of the distance between the swamp outside of Cochrane on the north to the rocky ridge crossing the country near Sesikinika on the south. The trunk road between Charlton and Englehart, and between Charlton and Long Lake is being graded; while road work is also in progress around Matheson.

AMERICAN SOCIETY FOR TESTING MATERIALS.

The American Society for Testing Materials in holding its 17th annual meeting this week at Atlantic City. The convention is divided into nine sessions terminating on Friday, July 3rd. Among the reports of committees which are being presented are the following:—Standard Specifications for Steel. This report is an exhaustive one and bespeaks an extremely active year for the committee. The recommendations occupy 106 pages and cover the proposed revisions in present standard specifications for steel and steel products; factor table and curve for values of elongation and reduction of area; proof tests of finished forgings; permissible variations in weight and gauge of sheared plates; proposed revised standard specifications for carbon-steel rails, for carbon-steel and alloy-steel forgings, for quenched and tempered carbon-steel axles, shafts and other forgings for locomotives and cars, for structural steel for cars, and for carbon-steel bars for springs. In connection with the proposed new standard methods of chemical analysis for plain carbon steel the report deals with the direct combustion and colorimetric method of determination of carbon and other methods for the determination of manganese, phosphorous, sulphur, silicon, copper, nickel and chromium.

The report upon standard specifications for wrought iron includes the consideration of the activities of sub-committees upon tubes and pipe; staybolt and engine bolt iron, chain iron, and iron chain.

The committee on the heat treatment of iron and steel presents a report on proposed recommended practices of (1) annealing of carbon-steel castings; (2) heat treatment of case-hardened carbon-steel objects.

Proposed standard specifications for coal-drawn steel are presented, together with tentative specifications.

The committee on magnetic testing of iron and steel submits a report which contained a number of recommendations in the existing specifications.

The committee on standard specifications for quicklime and hydrated lime is presenting specifications to cover each.

The most extensive committee report is that on preservative coatings for structural materials. The committee presents proposed standard definitions of terms used in paint specifications besides the reports of the various sub-committees, including those on paints, oils, turpentines and also on steel plates.

The committee on lubricants has a report outlining proposed provisional tests for lubricants. A minority report is being brought in with respect to viscosity.

The committee on standard testing for road materials recommends provisional tests and methods for: (1) determination of apparent specific gravity of rock; (2) determination of the absorption of water per cubic foot of rock; (3) making a mechanical analysis of broken stone or broken slag; (4) making a mechanical analysis of mixtures of other fine material with broken stone or broken slag. The report also contains proposed definitions of non-bituminous and bituminous road materials. A report is also brought in respecting regulations governing the form of specifications, in which a number of revisions are made.

Proposed standard specifications are brought in for strength tests, quality, design and construction of drain tiles.

The committee for the methods of sampling and analysis of coal is bringing in its second preliminary report.

Other reports being presented are on standard methods of tests, fire proof materials, non-ferrous metals and alloys, and standard specifications for copper wire, cement, brick, timber, rubber products and locomotive cylinders.

The annual report of the executive committee shows a membership of 1687.

The following are the papers being read at the various sessions:—"Magnetic Habits of Alloy Steels," by J. A. Mathews; "An Efficiency Testing Machine for Testing Drills, Caps and Dies," by T. Y. Olsen; "Are the Effects of Simple Overstrain Monotropic?" by Henry M. Howe; "Rubber Belting and Methods of Testing," by W. E. Campbell; "Report on Proceedings of Turin Meeting of the Council of the International Association for Testing Materials," by Henry M. Howe, Life Member of Council; "A New Vibratory Testing Machine and Results Obtained by its Use," by S. V. Hunnings; "Testing Concrete Aggregates," by Lloyd M. Chapman; "Some Considerations Affecting Specifications for Wrought Non-Ferrous Materials: Examination of Concrete Failures for their Determining Causes," by R. S. Greenman; "Specifications and Tests of Glue," by Oscar Linder and E. C. Frost.

CANADIAN ELECTRICAL ASSOCIATION.

The 24th annual convention of the Canadian Electrical Association was held in Montreal, June 24th, 25th and 26th, with the Ritz-Carlton as head-quarters. The president, Col. D. R. Street, of Ottawa, conducted the proceedings. Over 200 members and guests were in attendance. The convention was divided into morning and afternoon sessions and many instructive and valuable addresses were given. The entertainment of the delegates throughout the convention was very efficiently carried out. The entertainment committee, with Mr. Lawford Grant as chairman, made it a very pleasant occasion, particularly for the out-of-town members and visitors.

Among the papers presented at the technical sessions were the following:—"Modern Switching Equipment," by L. B. Chubbuck, Canadian Westinghouse Co.; "Maximum Demand Determination and its Relation to the Cost of Supply of Electrical Energy," by P. T. Davies, Montreal Light, Heat and Power Co.; "Legal Points in Connection with Central Station Matters," by G. H. Montgomery, K.C.; "Grounding of Distribution Circuits," by S. Bingham Hood, Toronto Electric Light Co.; "The Value of Electrical Heating Devices to the Central Station," by Harold S. Brown, Canadian General Electric Co.; "Some Notes on Steam Railway Electrification," by J. A. Shaw, Canadian Pacific Railway Co.; "Interruptions on Long Distance Transmission Lines," by P. Ackerman, Toronto Power Co. Numerous other papers and discussions were presented, together with reports on the work of various International Electric Light Association Committees. The election of officers for the coming year resulted as follows:—

President, Col. D. R. Street, sec.-treas. Ottawa Electric Co.; first vice-president, D. H. McDougall, sec.-treas. Toronto Power Company; second vice-president, R. M. Wilson, Montreal Light, Heat and Power Co.; third vice-president, Wills MacLachlan, Electric Power Company, Toronto; honorary secretary, T. S. Young, Hugh C. MacLean Co., Toronto; secretary-treasurer, Alan Sullivan, Toronto. Managing committee—J. S. Gould, Smith's Falls; G. W. Magalhaes, Toronto; P. T. Davies, Montreal; H. G. Matthews, Quebec; A. E. Dunlop, Pembroke; J. S. Norris, Montreal; George Kidd, Vancouver; Robin Boyle, Niagara Falls; W. G. Angus, Hamilton; W. S. Robertson, Toronto; E. L. Milliken, Sydney, N.S.; L. W. Pratt, Hamilton; H. R. Mallison, Montreal; H. Hulme, Montreal.

The next place of meeting was left to be decided by the managing committee.

Coast to Coast

Toronto, Ont.—The bridge at Sunnyside, Toronto, has been completed, and is now open for traffic.

St. Catharines, Ont.—Hydro-Electric was turned on in St. Catharines for the first time officially on June 27.

Vance, Sask.—Another gas and oil strike has been made at Vance, Sask., at a depth of 47 feet. Vance is located on the Winnipeg-Edmonton line of the C.P.R.

Calgary, Alta.—The latest report from the Street Railway Department of Calgary shows a gross deficit of approximately $70,000; and it is expected that this will be greatly augmented before the end of the year.

West Vancouver, B.C.—On property, known as George Mars' property, which is located half a mile due north of Dundarave station on the P.G.E. railway, oil has been discovered. It is proposed to form a company and to place stock upon the market almost immediately.

Winnipeg, Man.—The new elevated track at the C.P.R. depot, Winnipeg, is in operation. This track is about 6 feet higher than the present level of the station. The improvements at the depot are reported as proceeding rapidly. The track adjacent to the finished elevated track is being torn up preparatory to laying the foundations for the steel girders which will carry the tracks.

Montreal, Que.—While the big concrete conduit, which supplies Montreal with water from the St. Lawrence river, is being inspected in August by the New York experts, Messrs. Hering and Fuller, the emergency conduit from the Lachine canal will be used by the city. Contamination of the canal water will be prevented during the period of inspection and repairs—if any are found necessary—to as great a degree as possible.

Montreal, Que.—The section of the C.N.R. tunnel which extends from the upper end of the McGill University grounds to Cathcart street is now being lined with cement blocks, which are blocks weighing about one ton each. Some 40 or 50 feet of this lining has been put in position, and the work will be completed during the summer. The other sections of the tunnel have been bored practically through the solid rock and will not require this lining.

Vancouver, B.C.—The first section of the second new 18-inch water main, a 750-foot length of pipe, has been hauled across the First Narrows and has been placed in position. Some time ago, the work of hauling was commenced, but had to be stopped on account of ledges being encountered beneath the surface; and these had to be blasted away. Two other sections must be hauled across the Narrows, and will be connected under water.

Brantford, Ont.—Preparatory work for the raising of Lorne Bridge at Brantford is being advanced rapidly by the contractors for the work, P. H. Secord and Sons. The big abutment stones are being undermined and removed to make way for the new inner wall now under construction on both sides; and just as soon as these walls are completed, the bridge will be raised. This work is being carried on with very little interruption of traffic to and from West Brantford.

Lethbridge, Alta.—It is reported that work on the Thirteenth Street subway is progressing rapidly. The grading on the south side is practically finished; while, to the north of the regular main track of the C.P.R., piles have been driven, and a temporary trestle constructed. When grading on the north side is completed, trains will be run over the trestle while the work of excavation proceeds. The structure is to be completed by August 1.

Edmonton, Alta.—Mr. McArthur reports in connection with railroad construction on the E.D. and B.C. and on the A. and G.W. Railway, that 2,000 men are engaged on the former railway and 1,500 on the latter; that the big bridge over the Athabasca River at Smith will be completed in about one month's time; that the ballasting of the track between Edmonton and Smith will be completed in from 6 to 8 weeks; while, on the A. and G.W. Railway, the laying of steel is to be commenced at once.

Toronto, Ont.—First among the roads on the program of the provincial highways commission which will be surveyed and constructed, will be the road extending along the lake shore from Toronto to Hamilton. It has been decided to construct a substantially paved highway 20 feet in width, and to have it ready for traffic in the fall of 1915. A staff of 14 men are now engaged in a motor survey of the intervening district between the two cities; and following their report, legislation will be introduced to allow the letting of contracts and the immediate procedure with building.

Cranbrook, B.C.—Already the Cranbrook city council has commenced action in connection with the work covered by new money by-laws which have received the favorable vote of Cranbrook ratepayers. The water system which will be constructed will cost about $110,000, and will be one of the best in Western Canada. Mannesman steel pipe, the contract for the supply of which is now held by J. B. Turney and Co., Limited, of Lethbridge, Alta., will replace all of the old wooden pipe now in use. A supply of 110 cars of pipe, or over 5,000 tons, will be necessary.

Vancouver, B.C.—The G.N.R. bridge on Broadway avenue, Vancouver, has reached the stage of practical completion, and is being used for vehicular and pedestrian traffic. The bridge is 288 feet in length and 70 feet wide. The sidewalks are of cement, and the roadway is paved with wood blocks; while tracks have been installed on the bridge to provide for the possibility of a future extension of the street railway along Broadway. The G.N.R. company is now proceeding with the construction of abutments on the viaduct which passes over the Grandview cutting at Victoria drive.

Red Deer, Alta.—A press to manufacture pressed cement brick and building blocks is being started in Woodlands to the north of Red Deer, Alta. It is stated that in the manufacture of these brick, they are subjected to a pressure of 40 tons, and will stand a pressure test of 2,742 lbs. A brick was tested by placing it upon two blades 7 inches apart; and it took 850 pounds of pressure on a blade in the middle to break it. The press has a capacity of 5,000 bricks or 500 building blocks a day. The faced brick is manufactured plain, rock-faced, or ornamental, and of any color.

Winnipeg, Man.—Arrangements are now under way in connection with the erection of the big power plant which is to be built by the Winnipeg Electric Railway Company at Big Bonnet Falls, and which is to serve for the development of power not only for consumption by the street railway but for manufacturing purposes as well. The location at Big Bonnet Falls is about 70 miles north of Winnipeg. The plant will have a final capacity of about 150,000 h.p., and will cost close to $6,000,000. Only from 50,000 to 60,000 h.p. will be developed at first, or sufficient for immediate need.

London, Ont.—The engineers of the Hydro-Electric Commission who have been investigating the power possibilities of the northern peninsula, have sent in a report to the effect that over 22,000 h.p. of electric energy is available, and that the approximate cost of development would be $2,000,000. The Big Shute, purchased by the Commission for $400,000, is capable of delivering 6,000 h.p.; Port Severn, 1,200 h.p.; Eugenia Falls, 8,000; Wadsdell's Falls, 1,200; the Saugeen River, in Bruce, 4,000; and Swift Rapids, 6,000. The counties to be supplied from these sources are Simcoe, Ontario, Dufferin, Grey, Wellington, Bruce, and a portion of Huron.

Victoria, B.C.—It is given as an assured fact that towards the end of July, a service between Victoria and Courtenay over the new East Coast extension of the E. and N. Railway, will be opened. Steel-laying has now reached the Trent River, where the Dominion Bridge Co. is installing the last bridge which must be erected before entering Courtenay. This bridge is about 5 miles from the town; and since the viaduct will be sufficiently advanced for use in a week or so, rails will soon be carried into the temporary terminal and permanent divisional centre of this section of the Island railway. Arrangements are under way for the official inauguration of the service.

Port Nelson, Ont.—This year, early in July, the Dominion Government purposes despatching from Halifax to Port Nelson 5 steamers of materials and supplies necessary for the construction of the railway terminals, elevators, and harbor work at that port. Up to date, over $6,000,000 has been expended on the railway and terminals; and, at the session just closed, further appropriations were voted to the extent of $4,500,000 for the terminals and elevators. The Hudson Bay Railway has now been completed over half the distance from Le Pas. And, this year, the Government will undertake the construction of lighthouses and wireless stations on the Hudson Straits along the northern route to Port Nelson.

Hamilton, Ont.—Of the $620,000 which has been granted by the Dominion government for works at Hamilton, $250,000 is to be expended at Stipe's inlet on part of the harbor improvement scheme mapped out at Hamilton. The inlet will be deepened and widened, and large docks will be built, so as to afford good shipping facilities in the very heart of the industrial annex. $165,000 has been secured for the purchase of property and the commencement of work on the new customs house and post-office extension. $100,000 is the grant obtained for completing the work at the revetment wall; $50,000, for a wharf at the foot of Wentworth street; $40,000, for a new east end post-office; and $15,000 for improving the central post-office.

Edmonton, Alta.—In July, 1913, the Ulen Contracting Company, Chicago, commenced work on the contract of laying sewers in Edmonton. Since September 13 to the week ending May 30, over 1,000 feet of trunk sewers has been laid each week, while in one week, 1,142 feet were laid. In all 39,215 lineal feet have been laid, the sewers varying from 4.4½ inches to 6 inches in diameter. The sewers which have been laid by the company are those provided for in what is known as the Potter report, which was designed to prepare for a population of 200,000 people. Only about 1,900 feet remain to be laid, and the contract will have been completed, though the company has until the end of March, 1915, to fulfil its contract. The total value of the work is about $1,500,000; and it is the largest contract ever awarded by Edmonton officials.

North Vancouver, B.C.—On June 17, actual work commenced at North Vancouver upon the construction of the great dry docks and engineering works, including foundries, shipbuilding yards and graving docks, of the Dominion Shipbuilding, Engineering and Dry Dock Company. The incident was made the occasion of a ceremony, the nature and magnitude of the proposed works being pointed out to over 500 citizens of Vancouver. Already a large amount of money has been expended in clearing lands, in making roadways, and in planning and surveying the site, as well as in laying the water mains. According to the expressed intention of officers of the company, work will be vigorously pressed, and orders will be taken, as early as January of next year, when the first unit of the plant will have been completed.

Red Deer, Alta.—Seymour and Dawe, city engineers of Red Deer, have submitted to the city council a plan of the present and proposed sewerage system and a detailed estimate of the cost of the extensions, amounting, in all, to $101,394.60. The engineers were instructed in 1912 to proceed with a topographical survey for the purpose of preparing plans for extensions to the present sewer system. The plans presented indicate the rates of grade, elevations at intersections, location of manholes and depth of fill at all the principal points. The general idea is to construct a fairly large concrete or vitrified pipe trunk sewer with a storm outlet for the total sewage until such time as the city will be expected by the Provincial Board of Health to construct a sewage disposal plant, after which this storm outlet will only be used for storm water. The sewage disposal works are designed to be located some distance down the river.

Fort George, B.C.—The construction of the new winter road, which is to be built between Fort George and the Peace River district, is being urged upon the British Columbia authorities by the Fort George board of trade and the trade organizations of Vancouver and other coast cities. The road as at present planned will make use of all lakes, rivers and streams, cuttings being made so as to connect these natural winter highways, thus practically eliminating all grades, and providing the most convenient means of reaching the Peace River country before the institution of railway service. The road will follow the Giscombe Trail from Fort George to Giscombe Portage, along the Crooked River, with cut-offs in convenient places to shorten the mileage, across McLeod Lake, along the Missinchinka River to the Pine Pass, across the pass and down the Pine River to the Pouce Coupe country, with cuttings at various places to enable settlers to get down to the river easily.

Mount Dennis, Ont.—Work is now in progress at Kodak Heights, in Mount Dennis, on the plant of the Canadian Kodak Company, Limited, which is being erected at a cost of about $1,500,000. In the new plant, there will be seven buildings, with a floor area of more than 480,000 square feet, or about 11 acres. The largest building will be 460 feet long by 80 feet in width and 5 storys high. The plans call for reinforced concrete construction, with metal sashes and wire glass. In the seven structures, there will be used 2,500 tons of steel bars, 600 tons of fabricated structural steel, 80,000 square feet of metal sash, with 25,000 cubic yards of concrete requiring 45,000 barrels of cement. There will be a complete system of fire protection, consisting of outside hydrants, hose-houses and sprinkling systems for each building; and water for manufacturing purposes will be drawn from two concrete reservoirs with a capacity of 1,000,000 gallons. As Kodak Heights is about a mile beyond the limits of the city of Toronto, the water supply will be taken from 150-foot wells located on the company's property. The combined flow of these wells will be about 175,000 gallons per day. The manufacturing buildings proper will be located on a plateau, at the foot of which the power plant will be set. The contractors for the general construction of the plant are C. E. Deakin, Limited, of Montreal.

Vancouver, B.C.—The Vancouver and District Joint Sewerage Board is now advertising for tenders for the construction of what is officially known as Contract No. 2 of trunk sewer mains, which will cost at least $350,000. The work under this contract means the extension of a branch of the China Creek sewer to Central Park, with tributary mains to Gladstone, Collingwood and Earls road districts and a separate trunk sewer to Trout Lake. Contract No. 1, which is now under way, will probably be completed by November next. It covers the China Creek and Canoe Creek mains in wards Five and Eight and a portion of South Vancouver; and represents a cost of about $250,000. It is expected to com-

mence work on Contract No. 2 in August, and to have this completed within a year. The Joint Sewerage Board also proposes to proceed this year with the levelling of Burnaby Lake. When the water is at its lowest in July and August, it is intended to clean out the Brunette River from North road to the lake, and thus to increase the flow of water out of the lake, dropping the level several feet. This will have the effect also of increasing the flow from Still Creek, west of Burnaby Lake. The board will probably straighten Still Creek and endeavor to make it a better carrier of drainage water from this district. There is also a possibility that the sewerage board may take steps this season to extend the Balaclava main trunk in Kitsilano south to the city boundary line.

Fraser River, B.C.—The boring at the mouth of the North Arm of the Fraser river for the location of the best course for the channel in connection with the proposed harbor works, has proven satisfactory. The contract for this work was awarded to K. S. Robinson, of Vancouver. One hole sunk on the south of McMillan's Island, between that island and Sea Island, went down 45 feet and found nothing but sand and clay. Another off the Indian reserve was sunk 75 feet and down to 63 feet only sand and clay were encountered, when hard pan was struck. Several other holes have been bored at the mouth of the stream, and all have been equally satisfactory. Surveyors, also, are making current and water observations in the river, as well as surveying the foreshore and locating suitable places for test-boring. Also, good progress is reported on the construction of the long jetty at the mouth of the North Arm at the point of McMillan's Island. This, which will be 4 miles in length, will run parallel with and about 1,500 to 2,000 feet from the shore, and is being built by the Federal authorities for the protection of the channel, so as to prevent the sand from the sand heads silting up the channel, by the action of the tides. About a mile of bulkheading is already done, and work is now proceeding a mile further out towards the gulf, from the end of McMillan's Island, and directed landwards. Mattressing will be commenced when the jetty has progressed somewhat further.

PERSONAL.

J. C. NELSON, of Fort Rouge, Man., has been appointed traffic superintendent on the new railway in connection with the Greater Winnipeg Water District. Mr. Nelson has been in railway work for 23 years. In 1907 he joined the staff of the Northern Pacific Ry., at Winnipeg.

R. W. LEONARD, C.E., is resigning his position as commissioner of the National Transcontinental Railway, and the Department of Railways and Canals, Ottawa, will assume charge of his duties. It is reported that F. P. Gutelius, general manager of the Intercolonial Railway will be given charge for the Government of its whole system of railways —i.e., the I.C.R., the N.T.R. and the Hudson Bay Ry.

OBITUARY.

From Brandon, Man., comes the report of the death of Arch. M. Leitch, for many years a prominent contractor on the western lines of the Canadian Pacific Railway Company. Mr. Leitch was born in Argyle, Scotland, 66 years ago, and at the age of 36, became engaged in railway building in Canada.

An extremely sad fatality occurred at Copper Cliff, Ont., on the morning of June 25th, when Fred. J. Bedford, a '08 graduate in mining of the University of Toronto, was instantly killed while examining the mechanical operation of a skip in Mine No. 2 of the Canadian Copper Company.

Mr. Bedford had proceeded to the 10th level and was stationed at the side of the shaft when, owing to a mistaken signal, the skip descended upon him from the 9th level, causing instant death.

Mr. Bedford entered the employ of the company in 1908. Shortly afterward he proceeded to Porcupine and took charge of the Dome Mine at its opening. Later he entered into private practice in a consulting capacity and in assessment work. In November, 1913, he returned to Copper Cliff where he had since occupied the position of shift boss of No. 2 mine.

COMING MEETINGS.

AMERICAN SOCIETY FOR TESTING MATERIALS. —Seventeenth Annual Meeting to be held in Atlantic City, N.J., June 30th to July 4th, 1914. Edgar Marburg, Secretary-Treasurer, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS.—Summer convention to be held at Brighton Beach, N.Y., July 3rd and 4th, 1914. Secretary, J. R. Wemlinger, 11 Broadway, New York.

UNION OF CANADIAN MUNICIPALITIES.—Annual Convention to be held in Sherbrooke, Que., August 3rd, 4th and 5th, 1914. Hon. Secretary, W. D. Lighthall, Westmount, Que. Assistant-Secretary, G. S. Wilson, 402 Coristine Building, Montreal.

WESTERN CANADA IRRIGATION ASSOCIATION.— Eighth Annual Meeting to be held at Penticton, B.C., on August 17, 18 and 19. Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

AMERICAN PEAT SOCIETY.—Eight Annual Meeting will be held in Duluth, Minn., on August 20th, 21st and 22nd, 1914. Secretary-Treasurer, Julius Bordollo, 17 Battery Place, New York, N.Y.

CANADIAN FORESTRY ASSOCIATION.—Annual Convention to be held in Halifax, N.S., September 1st to 4th, 1914. Secretary, James Lawler, Journal Building, Ottawa.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown, Indianapolis, Ind., Secretary.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.— 11th Annual Convention; 5th American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau St., New York, N.Y.

The Ottawa branch of the Canadian Society of Civil Engineers announces the date of its annual meeting as the first Wednesday in October. During the summer months the rooms at 177 Sparks Street will be closed.

ORDERS OF THE RAILWAY COMMISSIONERS OF CANADA

Each week on this page may be found summaries of orders passed by the Board of Railway Commissioners, to date. This will facilitate ready reference and easy filing. Copies of these orders may be secured from *The Canadian Engineer* for small fee.

22011—June 13—Amending Order No. 21751, dated April 29th, 1914, by striking out paragraphs 4, 5 and 6 of operative part of Order.

22012—June 16—Relieving G.T.R. from providing further protection at crossing of Waterloo St., town of New Hamburg, Ont.

22013—June 17—Approving proposed Supplement No. 3 to Canadian Freight Classification No. 16, as finally revised and submitted for approval by G. C. Ransom, Chairman, Canadian Freight Association, by letter dated at Montreal, June 10th, 1914, and with which is consolidated Supplement No. 2 approved by Order No. 20967, Dec. 10th, 1913, to become effective with the least delay necessary, subject to certain provisions.

22014—June 17—Authorizing G.T.R. to construct siding into premises of John R. Booth, on Lot 29, Con. 2, Tp. Dickens, District Nipissing, Ont., near Opeongo.

22015—June 17—Authorizing G.T.R. to construct siding and spur therefrom, into premises occupied by Ross, Church Road Co., Limited, Lot 260, 6th Range, Tp. Godmanchester, Co. Huntingdon, Que.

22016—June 17—Approving city of Montreal plans No. B-1-1342-1 and No. B-1-1342-2, showing diagram of material and general details of steelwork and details of sidewalk brackets, of subway proposed to be constructed under C.P.R. at Park Ave., Montreal.

22017—June 17—Authorizing G.T.R. to construct siding into premises of Interprovincial Brick Company of Canada, Limited, on Lot 29, Con. 5, Tp. Chinguacousy, Co. Peel, Ont., near Cheltenham.

22018—June 15—Authorizing Dominion Stock and Bond Corporation to construct subways at Corporation and Government Streets, under G.T.P. Ry., town of Fort Fraser, B.C.

22019—June 16—Authorizing C.N.R. to operate trains over railway between Saskatoon and Harris, 49.4 miles, at speed not exceeding 25 miles an hour, instead of 20 miles. And relieving company of speed limitation of 15 and 20 miles an hour over portion from Harris to Kindersley, 76.7 miles.

22020—June 18—Approving plan showing alterations and additions to C.N.R. Co.'s station building at Alsask, Sask.

22021—June 16—Approving and authorizing clearances, as shown on G.T.R. plan, of bridge over siding to premises of Dominion Tire Co., Limited, Berlin, Ont., subject to certain conditions.

22022—June 17—Authorizing G.T.R. to construct siding into premises of Dominion Glass Co., Limited, Toronto, Ont.

22023—June 18—Authorizing G.T.R. to construct siding into premises of Kirkfield Portland Cement Co., Limited, Lot 18, Con. 2, Tp. Somerville, Co. Victoria, Ontario.

22024—June 16—Authorizing C.P.R. to construct Bassano-Easterly Branch Line across fifty-eight (58) highways, mileages 0.82 to 50.95, with some diversions.

22025—June 17—Extending, until August 1st, 1914, time within which C.P.R. install electric bell at crossing of highway at Port Haney, B.C.

22026—June 18—Relieving Michigan Central R.R. from maintaining day and night flagman at crossing of highway about 2 miles west of Mull, Tp. Harwich, Ontario.

22027—June 18—Authorizing C.L.O. & W. Ry. (C.P.R.) to include within limits of right-of-way shown in plans approved under Order Nos. 17024 and 17105, lands edged in red on plan referred to in book of reference dated June 8th, 1914.

22028—June 10—Authorizing City of Vancouver, B.C., at own expense, to construct highway over V.V. and E. Ry. and Nav. Co., at Venables St.

22029—June 8—Directing that Esquimalt and Nanaimo Ry. file plans showing culvert sufficient to properly drain lands of Adam Gordon, Hillbank, B.C., for approval of Engineer of Board; work be completed to satisfaction of Engineer of Board within 2 months from date of approval of plans; and be done at expense of Ry. Co. Upon completion of work Adam Gordon pay to Ry. Co. sum of $50.00 towards expense of said work.

22030—June 22—Authorizing C.P.R. to open for traffic double track from Herbert to Notman, mileage 91.9 to 95.1. Sask.

22031—June 22—Granting leave to Government of Sask., at own expense, to construct highway over C.P.R. blind line north of Sec. 15-30-22, W. 2 M., Sask.

22032—June 22—Authorizing G.T.R. to construct siding into premises of Welch Grape Juice Co., Lot 21, Con. 6. Tp. Grantham, Ont.

22033—June 22—Approving location C.N.O.R. station grounds at Vaughan, Tp. Deacon, Dist. Nipissing, Ont., mileage 151.1 from Ottawa.

22034—June 23—Authorizing C.N.R. to construct across 37 highways, mileage 44.84 to 93.85, Sask.

22035—June 22—Granting leave to Winnipeg, Selkirk and Lake Winnipeg Ry. to cross, for construction purposes only, until September 1st, 1914, Selkirk Branch of C.P.R. Applicant operate its trains over crossing between hours of 6 a.m. and 11 p.m.; during these hours crossing be protected by watchmen, appointed by C.P.R., at expense of applicant—watchman be supplied with C.P.R. train time table, and if possible be notified by it of any extra train requiring to make the crossing during the hours of operation by Applicant.

22036—June 17—Approving agreement between Bell Telephone Company and Caradoc-Ekfrid Telephone Company, Limited, dated June 9th, 1914.

22037—June 22—Authorizing Shale Products, Limited, to construct aerial tramway over Hamilton and Allandale Branch of G.T.R. near Inglewood Jct., Ont., subject to certain conditions.

22038—June 18—Authorizing Department Railways and Canals to construct Welland Ship Canal Construction Ry. across N. St. C. & T. Ry. at Lake Shore Road, Port Weller, Ont., subject to and upon certain conditions. Department to bear and pay whole cost of providing, maintaining interlocking plant.

22039—June 19—Amending Order No. 20240, Sept. 2nd, 1913, by adding clause,—"The Ry. Co. bear and pay cost of filling side ditches and installing crossing planks, cattle guards, and culverts."

22040—June 20—Authorizing G.T.P. Ry. to construct across Government Road Diversion, N.W. ¼ Sec. 24-53-7, W. 5 M., mileage 60.2, Dist. North Alberta, Alta.

22041—June 19—Authorizing G.T.R. to construct siding into premises of Pilkington Bros., Limited, Lot 5, Con. 2, Tp. Wainfleet, Co. Welland, Ont., and west of Port Colborne.

22042—June 22—Amending Order No. 19199, dated May 6th, 1913, in so far as diversions on plan covered by said Order are concerned.

22043—June 19—Authorizing C.P.R. to construct siding for G. A. MacIver, Sherbrooke, Que., from point on southerly limit of main, mileage 19.66, Megantic Sub. Div., Lot 544, R. 1, Victoria North, Tp. Hampton, Co. Compton, Que.

22044—June 20—Authorizing Lake Erie and Northern Ry. to connect with T.H. & B. between station 866-92.5, equal to 00-00, in village of Waterford, and station 58-95.4, Tp. of Townsend, Ontario.

22045—June 11—Dismissing application B. C. Express Co. for Order directing G.T.P. Ry. to remove temporary bridge built across Fraser River below confluence with Nechaco River, and make openings in permanent steel bridge across Fraser River, at Ry. Mile No. 142; also Mile No. 189, etc.

Volume 27. Toronto, July 9, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

SUBSTRUCTURE OF THE QUEBEC BRIDGE.

COMPLETE RESUME OF THE CONSTRUCTION OF THE PIERS AND ABUTMENTS—SOME INTERESTING CAISSON SINKING FOR THE SOUTH MAIN PIER—PLANT OPERATION.

By H. P. BORDEN,
Assistant to Chief Engineer, Quebec Bridge Commission.

NOTE :—The construction of the new Quebec Bridge is a most illustrative piece of engineering, and has been closely followed, since its beginning, in the columns of THE CANADIAN ENGINEER. *The substructure, now complete with the exception of a few finishing details mentioned in the first paragraph below, is a vital part of the world renowned undertaking, and engineers of all countries have been interested in its progress. In the following article Mr. Borden has reviewed for us its entire construction. For greater detail respecting the piers and abutments the reader is referred to previous issues of* THE CANADIAN ENGINEER *as follows : July 14, and Oct. 6, 1910 ; June 13, 1911 ; Oct. 31, 1912 ; Feb. 13, 1913, and April 9, 1914. These deal with their design and constructional progress. Other articles appearing in various issues refer similarly to the superstructure.*
—*EDITOR.*

THE contract for the construction of the piers for the Quebec Bridge was awarded to Messrs. M. P. and J. T. Davis, of Quebec, in February, 1910. This work has been continued constantly since that date, and is now practically completed with the exception of pointing and cleaning the masonry and dressing the bridge seats.

This contract, as finally completed, is divided into the following units: North abutment (alterations), 404.5 cu. yds. ; north intermediate pier, 1,665.6 cu. yds. ; north anchor pier, 17,736.0 cu. yds. ; north main pier, 31,870.4 cu. yds. ; south main pier, 38,279.4 cu. yds. ; south anchor pier, 16,073.0 cu. yds. ; south abutment (alterations), 61.1 cu. yds. Total, 106,090 cu. yds.

At the start, a careful study was made by the board appointed by the government, to determine whether it was possible to use the old masonry. After a thorough investigation it was found that, owing to the increased weight of the steelwork, all the old masonry, with the exception of the abutments, would have to be taken down and new piers constructed. It was, therefore, decided to move the whole bridge to the south about 65 ft., retaining the original longitudinal centre line. This brought the north main pier further into the water and the south main pier the same distance towards shore, the same centre to centre length of span of 1,800 ft. being retained. It was impossible to place the south main pier nearer the river on account of the wreckage which lies in the water at that point.

Before the contract was awarded, a series of borings were made at and about the location of the two main and anchor piers. Nineteen borings in all were taken, each boring penetrating at least 15 ft. into solid rock in order to make sure that it was bed rock rather than a boulder that had been struck. These borings showed that bed rock would be encountered approximately at El. 0.0 on the location of both north and south main piers, which elevation was about 101 ft. below extreme high water and 70 and 85 ft. below the bed of the river on the north and south sides respectively. The formation of the bed of the river on the two sides, however, was found to be totally different. On the north side heavy boulder formation was encountered for the entire depth, the boulders being closely packed together with coarse sand and gravel. On the south side the borings showed sand formation for the entire depth with only a sprinkling of boulders at various points. The bed rock was a hard sand-stone, called "Sillery grit," overlaid with a red and gray shale. On the south side 2 ft. of hardpan overlaid this shale.

The caisson for the north main pier was started first and was constructed at Sillery, about 3 miles down the river. This caisson was 180 ft. long and 55 ft. wide. It was constructed of 12 x 12-in. southern pine with a cutting edge of the same material 30 in. square. This cutting edge was shod with a 6 x 12-in. oak timber instead of the steel shoe, as usually used. It was claimed in this case that if any distortion of the caisson took place the steel shoe would tend to prevent the caisson from readily readjusting itself—as would be the case with a wooden shoe—and that the wooden shoe gave sufficient service during the process of sinking. The caisson had a working chamber 8 ft. high in the clear, divided by longitudinal and transverse bulkheads into 18 compartments. It was built in the winter under a construction shed, thus enabling the men to work without interruption from the weather. The caisson was built over launchways with a 10% grade which led out into deep water. The walls of the caisson were built up about 40 ft. before it was launched. When ready for launching, the caisson was lowered down to its inclined position on the launchways by means of heavy jacks. When everything was ready an impetus was given by jacks placed at the rear horizontally, and launching was effected without mishap.

It was towed to the bridge June 14, 1910, and placed in position over the site which had been previously dredged to an average depth of about 20 ft. in order to push ahead the work of sinking as fast as possible.

The work of filling it with concrete was started immediately and some 2,000 yds. of concrete had been deposited before the caisson began to touch bottom as its

corners. The caisson was leaking to a certain extent, but could be readily kept dry by means of two pumps. At this time, however, an accident happened to the boiler equipment and before it could be repaired the caisson had been filled with water to such an extent that it grounded on an uneven bottom. The result was that the caisson was seriously strained and the seams opened up to such an extent that it was found impossible to keep air in the working chamber. It was decided to remove the concrete from the caisson and tow it to St. Joseph de Levis and have permanent repairs made there during the coming winter.

In view of this accident a re-consideration of the masonry design was made by the board, with the result that it was decided, in consequence of the difficult sinking on the north side, to use two caissons for the north main pier and to use the reconstructed larger caisson for the south side, where the sinking operations would be much simpler and the material to be penetrated would be, as shown by the borings, composed mostly of sand. This entailed the abandonment of the enlargement of the south main pier and meant the sinking of a caisson south of the old pier and entirely distinct from it. It was, therefore, decided to sink this new large caisson, or caisson No. 1 as it has been designated, 65 ft. nearer the shore, or south of the existing main pier, and to sink the caissons for the north main pier the same distance towards the river, or south of the existing north main pier, thus making the span 1,800 ft.—the same as that of the original bridge. This change in the plans allowed the board to keep the centre line of the bridge coincident with that of the old structure which was a very important item, as it would avoid the large expense of changing the location of the railroads approaching both ends of the bridge.

It was found that caisson No. 1 could be satisfactorily repaired in dry-dock, and on May 28, 1911, it was floated out and towed up the river about nine miles to the site on the south side which, being exposed at low water, had been carefully levelled off. At extreme high water there is about 15 ft. of water over this prepared bed. As the caisson from its construction had a pretty deep draught, a false bottom was constructed with a view to decreasing this draught before floating into position. The result was that the caisson floated with a draught of 11 ft. and was placed in its exact position for sinking without serious difficulty.

The openings in the various shafts were then left unobstructed in order that the rise and fall of the tide would not lift the caisson from its permanent bed. This caisson was left in this position throughout the season of 1910, the work of the contractor being directed towards the sinking of the caissons on the north side of the river.

Caissons Nos. 2 and 3, for the north main pier, were constructed at Sillery on the same location as caisson No. 1, the same details of construction being followed throughout. Each of these caissons were 85 ft. long by 60 ft. wide. No. 2 was started June 15, and No. 3 on June 29th, 1911. Both these caissons reached their permanent location at El. 20.0 about October 20th, 1911.

The average rate of progress of sinking the westerly caisson (No. 2) was 0.37 ft. per day, and that of the easterly caisson (No. 3) 0.47 ft. per day. It was the original intention to sink these caissons to rock, but as the work progressed the sinking became more difficult, and finally, when the caissons had reached El. 20.0, it was considered that the foundations at this point were quite satisfactory for many times the load that the piers would be called upon to carry.

Bearing tests were made at this point to determine the supporting value of the foundation. A cube of granite 2 ft. square was placed on an average section of the bottom and over this was placed a lever composed of 2 I-beams supported on pin bearings. The short end of the I-beams was supported against the roof of the caisson. A hydraulic jack was placed to exercise a definite load at the end of the longer lever arm. A load of 59 tons per sq. ft. showed a settlement of only ⅛ in., practically no settlement at all being noticed at 20 to 30 tons. As the average working load at the foot of this pier was only 8 tons per sq. ft., it was considered that the board would not be justified in carrying the foundations to a lower level.

In the operation of sinking these caissons, the contractor met with considerable difficulty owing to large bounders fouling the cutting edge, and in several places this cutting edge was forced inward from 6 to 10 in., and, as it was feared that if the sinking was continued in the same manner this cutting edge would be further distorted and sinking operations endangered, the method of sinking was then changed so as to avoid any such contingency.

Timber blocking was placed beneath the bulkheads and at the centre of the chambers. A trench was then excavated all around and below the cutting edge and for several inches outside the exterior surface of the caisson. This trench was excavated to a depth of about 2 ft., after which it was filled with blue clay in bags and when all was ready the blocking was under-scoured with water jets and the caisson lowered on a cushion of clay. The clay tended to act as a lubricant and also prevented considerable air leakage, and as all boulders were removed from beneath the cutting edge before the caisson was lowered, all further damage to the cutting edge was prevented, and it was found that the sinking was carried on even more rapidly.

After the caisson had reached its final location the working chamber was filled with concrete composed of one part of cement, two parts of sand, and four parts of small crushed stone. This concrete was made much drier than the concrete used in the main caisson, it being found that concrete deposited under compressed air gave better results when very dry than in a more or less liquid state.

Concrete was deposited in terraces, the men working towards the centre from the sides and ends. Great care was taken to ram the concrete thoroughly round the roof timbers so that a bearing would be assured under the roof of the working chamber. After the working chamber was filled as carefully as possible by hand the shafts were filled with concrete. As a still further precaution, a rich grout was forced in through 4-in. blow pipes by compressed air under a pressure of 100 pounds per sq. in. One hundred and fifty-four bags of cement were used in grouting caisson No. 2, and 274 for caisson No. 3.

Caissons Nos. 2 and 3 were sunk with 10 ft. space between the two ends, thus making the overall length of the two caissons 180 ft., the same as No. 1. After they had been filled with concrete, the space between them was dredged by a clam-shell bucket to a depth of 25 ft. below high water, the boulders and hard sand being excavated with considerable difficulty. Shutters 40 ft. high, made of 12 x 12-in. timbers, were placed vertically against the outside walls of the adjacent caissons so as to close each end of the space between the caissons and overlap about 12 in. on their sides. The bottoms of the caissons were banked up on the outside with clay dumped in the river and covered with heavy rip-rap. The shutters were securely bolted to the caisson walls down to low-water level, and thus formed coffer dam walls enclosing this space between the caissons. This space was then filled with concrete deposited under water up to an elevation of 7 ft. below low-water mark. After the concrete was de-

posited the water was pumped out and the space between the caissons was then bridged by six old steel girders, 6 ft. deep, resting in pockets left in the concrete in the adjacent ends of the caisson, the wooden walls of the caisson having been cut away to allow this to be done. Afterwards the concrete was deposited in a continuous mass in and between both coffer dams and caisson, thus forming a monolith upon which the masonry shaft of the pier could be carried. The masonry of the pier was then built up inside of the crib work, which was kept in place until the mason work had extended above high water.

The sinking of the large caisson for the south main pier was started July 28, 1912, and was completed October 24, 1912, or at the rate of 0.75 ft. per day during the entire period. The material encountered at this point was, as indicated by the borings, chiefly sand, and required that the pier be carried down to rock, which was reached at El. 0.0, 101 ft. below high water, and 86 ft. below the bed of the river. The difficulty experienced on the north side in keeping the cutting edge intact, and also on account of the fact that the caisson had previously been overstrained, and the fear that it might yet be weak, led the contractors to take unusual precautions to prevent the possibility of any accident happening to the caisson during the sinking operations. For this reason, special appliances were devised for relieving the cutting edge from carrying all the load, and by the use of sand-jacks the total weight of the caisson was distributed over the entire bottom area. The manner of using these sand-jacks was one of the most interesting features connected with the sinking of this caisson, and possibly merits especial description.

The jacks themselves were of very simple construction. The cylinders of the sand jacks had an internal diameter of 31 in., and were 36 in. long, constructed of ¼-in. steel plate with 4-in. lap joint; two angles 1½ x 1½ x ¼-in. reinforced the cylinder at top and bottom. The piston was a block of yellow pine 2½ ft. square and 5 ft. long. Four feet at one end was round with a diameter of 29 in., thereby allowing 1 in. play in the cylinder. The lower end of the piston was reinforced by a 2½ x ⅜-in. welded iron band. During operation the piston was attached rigidly to the roof of the working chamber by long screw bolts, and remained there permanently during the entire period of sinking.

In preparing for a drop, the first step was to excavate a hole under the piston. The cylinder was filled about ⅔ full of sand, placed in position under the piston, and blocked up hard against it by means of timbers. While this was being done the caisson was supported on timber blocking under the bulkheads and other points. At the bottom of the sand-jack was a 2-in. iron pipe extending entirely across the cylinder, the centre of which was split and opened up to allow the sand to escape. This type had no bottom to the cylinder, the timbers acting as a support for the sand. Another type used had a steel bottom and two 3-in. holes with sliding cover at each side at the foot of the cylinder. The operation in both cases was the same.

When everything was ready for a drop, the timber blocking supporting the caisson was undermined by a water jet and the full load taken by the sand jacks. A man was stationed at every jack, and at a given signal, afforded by the flashing of electric lights, each man turned a hydraulic jet with 60 lbs. pressure into the hole at the bottom of the cylinder, thus washing the sand out. The sand was caught in canvas bags of uniform size. When the canvas bag was full the lights flashed again and the water jet was turned off. Another bag was then obtained, and at the signal the jet was again turned on and the bags filled. Each cylinder contained in the neighborhood of 16 bags of sand. This operation was continued until the required settlement was obtained. By adopting the signal system and emptying the sand into bags, it was possible to guarantee that the whole caisson was being sunk at a uniform rate, and that there was no reasonable possibility of any part of the caisson being strained by being sunk more rapidly than another portion. As a rule, a drop of from 1½ to 2 ft. could be effected at each operation, the recurrence of the operations depending entirely on the nature of the material to be removed. When the drop had been finished the blocking was again placed under the bulkheads to take the load of the caisson, and the holes under the sand-jacks deepened in order that the operation might be repeated. The greater part of the material excavated in this caisson, being sand, was forced out through blow pipes.

Practically no problems were encountered in the construction of the north and south anchor piers and the north intermediate pier. Both anchor piers were constructed on a location south of the existing anchor piers. For the north anchor pier a coffer dam had to be constructed around the foundations since the foot of the pier was below high-water mark. The south anchor pier was well above high-water mark, so that all excavation was in the dry.

The anchorage girders were embedded in concrete and the first length of anchorage eyebars set in place, two shafts being left in each anchor pier for connecting up the anchor eyebars of the main anchorage. It is the intention ultimately to embed the bottom section of eyebars in concrete, but this will be deferred until they receive the full dead load stress.

The concrete used in the caisson and backing of the piers was 1:2½:5 by volume, except the concrete in the working chamber, which was 1:2½:4. The cement was required to pass a tensile test for neat cement of 450 and 540 lbs., for 7 and 28 days respectively; and for 1 part of cement and 3 parts of sand, 140 and 220 lbs. respectively. For the main piers entirely new quarry cut stone was used. For the anchor and intermediate pier the specification allowed the use of stone from the old masonry. The greater portion of the old stone demolished from the old masonry was consequently used in the construction of these piers. The abutments were not radically changed, it being only necessary to raise the ballast walls and make minor alterations to suit the new design.

The masonry in the pier shafts consists of grey granite rock faced ashlar, laid with alternate headers and stretchers and backed with concrete, in which were embedded displacer stones usually about 1 cu. yd. in size. Headers were required to have a length of at least 2½ times their build, with a minimum length of 7 ft. Bed joints were ½ in. throughout and vertical joints ⅜ in. for 12 in. back from the face and not exceeding 4 in. wide at any point.

All stones in rounded ends of main piers were clamped together and connected vertically by dowels. The upper 18 ft. of these piers were built with cut granite backing. About 40% of the stones in these backing courses were made to project up through the course above, in this way giving a very strong vertical bond. The bridge seats proper are built 2 ft. higher than the surrounding upper coping course, and are 4 ft. deep, extending to the bottom of this coping, thus providing heavy stones under the main bearings.

The anchor piers are in plan about 136 ft. long by 29 ft. wide at the bottom, with a batter of 1 in 24, and re-

duced in section for 41 ft. at the centre to a vertical wall 18 ft. thick, thus forming pilasters at the ends, through which the anchor wells are built.

Owing to the importance of the work, the contractor spared no effort or expense to provide a plant up-to-date in every respect.

On the north side a large wooden trestle was built around the four sides of the caissons, all supported on piles and cribs. As the current here reaches 7 miles per hour and there is an average tide of 16 ft. and a maximum of 20 ft. it was necessary to have this trestle very strongly built. Platforms extended to the shore from the up- and down-stream ends of the pier carrying standard gauge double tracks which formed loops around the caisson and connected with the concrete plant 600 ft. inshore and located at the foot of the cliff.

The power plant, dining-room for "sand-hogs," and two-story bunk house were also located at the water's edge—just upstream from the pier. All supplies and material required were received by rail or team at the top of the cliff, some 160 ft. above high-water level and were delivered by gravity to the concrete plant and service tracks at the foot. A service elevator was operated by cable and hoisting engine at the top of the cliff which was an angle of about 45° at this point connected the tracks at the top with those at the bottom. A stairway provided means for the men to reach the upper and lower levels. The board of engineers' office was located at the top of the cliff.

At the foot of the cliff were situated the mechanical plants which furnished the power for the various operations. To supply compressed air, five Ingersoll-Sargeant compressors were employed. Four had a capacity of 1,250 cu. ft. and one 2,500 cu. ft. per min. These compressors discharged into a 12-in. main from which 7-in. branches led into the two caissons. Each branch was fitted with a gate valve so that the air could be cut out of either caisson at will. The main pipe was carried in a sluice of running water about 400 ft. long, which kept the temperature of the air down to about 75° F. As a consequence, the temperature of the working chamber rarely exceeded 90° F., although the service shaft, on account of the heat generated by the setting of the concrete around it, generally exceeded 100° F. For this same reason the temperature of the working chamber reached as high as 110° F. when being finally filled with concrete.

The compressors were at first supplied with power from six 100-h.p. horizontal boilers. As the work proceeded it was found that the demand on the compressors was greater than was anticipated. As a consequence, an extra 100-h.p. boiler was installed, together with one 500-h.p., one 75-h.p. and one 250-h.p. boilers, making a battery of 10 boilers, aggregating 1,075 h.p. These boilers were all coupled up, and in addition to the compressor plant, supplied power to the power-house, rock crusher and concrete mixing plant. There were also one 100-h.p. vertical and two 50-h.p. horizontal boilers on the platform near the caissons, and were used to furnish power to six 15-ton stiff-leg derricks which were used for handling stone, concrete, etc., during the sinking operations. They also furnished power to one 8-in. high-pressure pump used for washing material in the working chamber and to two 4-in. pumps which supplied water to the high-level tank on the top of the hill, thus furnishing the water supply for the whole plant.

The plant was supplied with electric light from its own power set situated near the boiler-house. It was equipped with a 30-kw. C.G.E. generator, capable of operating 16 arc lights and 100 incandescent lights (16 c.p.). There was also a blacksmith and machine shop in connection, so that all minor repairs to plant and equipment could be made on the job.

The concrete mixing plant was placed just at the foot of the cliff. Half-way up the slope was the rock crushing plant. The rock used for the concrete was obtained from an adjoining cut and was brought to the brow of the hill in cars which dumped into a chute leading to the crusher plant. The stone was fed into 2 gyratory crushers which were capable of dealing with about 500 cu. yd. in 12 hours. After passing through the crushers the stone was led over an inclined screen of 2-in. mesh, and thence into a storage hopper bin of about 200 yds. capacity. These chutes led from this to the concrete mixing platform below, the mouth of each chute being directly over a mixer. From this platform the sand, stone, cement and water, were fed in the proper proportions to the mixers underneath the platform, which in turn dumped into self-discharging buckets on trucks, which were hauled to the caissons by horses. Three Ransome mixers were used on the work, two having a capacity of ⅔ cu. yd. and the other 1⅓ cu. yds. Owing to the conditions under which the work was carried on the mixers never had a chance to work to their full capacity; their best day's work being 450 cu. yds. for the 24 hours.

The sand used in the concrete was conveyed to the concrete mixing platform in the same manner as the stone, i.e., by means of a chute from the upper level, where it was unloaded from hopper bottom cars. The chute was 8 ft. wide by 6 ft. high and was kept practically full all the time, the sand being taken from the lower end as required. The coal for the boilers was also delivered from the upper level through a chute, which emptied into 2-yard side-dump cars at the boiler-house level. By means of a track these cars delivered the coal to each boiler-house as required. On the top of the coal chute was a double line of rails with balanced trucks, which conveyed the cement from cars at the upper level to the storage shed at the level of the concrete mixing platform. The cars could, therefore, be unloaded as they arrived and the cement placed where required for use with the minimum amount of handling.

For the convenience of the "sand hogs," who were compelled to work on shifts through the whole 24 hours, the contractor erected both sleeping and dining quarters for a large number of his men. On the lower level a bunk-house had been provided to accommodate about 100 men, and a dining room that would seat as many more. On the upper level was a similar house with bunks for about 60 men and dining quarters of about the same capacity. On the dock the contractor erected a number of buildings, which included an office and bath accommodation for the inspectors, a hospital with a doctor in continual attendance, where first aid might be administered in case of serious accidents, or regular treatment in case of minor troubles. There was also provided a coffee-house, kept at a high temperature, where the "sand hogs" could change their clothes and receive hot coffee at the end of their shift in the working chamber. In addition to the above were the usual stores, offices, etc., for the contractor's own use. In connection with the hospital arrangements there was also provided a steel hospital tank connected with the compressed air system, to which men suffering from the "bends" could be immediately transferred and treated.

For serving each caisson four 30-in. shafts for material and two 30-in. ladder shafts were employed. For ejecting the sand and smaller stones four 4-in. blow pipes were used. The larger boulders were broken up and

hoisted through the material shaft in buckets having a capacity of ⅔ cu. yd. Four 7-in. compressed air pipes supplied air to the working chamber and served the blow pipes. Two 6-in. pipes supplied the water for "washing" the sand. One 2-in. pipe supplied high-pressure air for drilling, etc., and a second 2-in. pipe carried the wires for the electric lighting of the working chamber and ladder shaft.

As soon as the sinking was completed on the north shore as much of the plant as could be spared was moved to the south side. The men's dining-rooms and sleeping quarters were placed on skids, launched into the river, floated across, and placed in position on the other side. The layout for the mixing plant, sand chute, coal chute, etc., was practically the same as on the north side of the river, all the materials being led to the lower level by gravity. The stone for the crushers was quarried directly from the top of the cliff so that one derrick could pick up the stone in the quarry and deposit it in the hopper leading to the crushing plant half-way down the cliff. While the boiler and compressor plants used on the south side were drawn as much as possible from the north side, yet they had to be materially increased. The steam plant included three 125- and one 250-h.p. Heine boilers, twelve 100-h.p. locomotive boilers, and seven Ingersoll-Rand and Ingersoll-Sergeant air compressors delivering to 2 coupled receivers from which a pair of 12-in. mains led to the caisson and were carried for about 200 ft. in a wooden flume constantly filled by water. This reduced the high temperature developed at the compressors to about 80° in the working chamber of the caisson. There were also two 12-in. Worthington high-pressure pumps which delivered water to the caisson for the hydraulic jets used for excavation.

On account of the very high tide which prevailed at the site, the air pressure in the caissons constantly varied and was controlled by an operator in the compressor house who adjusted it to correspond with the indications of an automatic register showing a continuous tide pressure.

The stone from the quarry on the top of the cliff was delivered by derricks into a No. 8 McCully rotary crusher near the top of the bank, which broke the larger pieces and delivered them through a chute to a No. 5 Allis-Chalmers crusher about 25 ft. below it. The second crusher reduced the stone to a diameter of 2 in. and delivered it through another chute to a storage bin adjacent to the sand bin. Both stone and sand bins delivered by gravity through gates to measured compartments in a triple charging hopper just below the floor of the working platform. This hopper was lined with steel and had a compartment into which the requisite number of bags of cement were poured by hand. The hopper gate was operated from the charging platform and delivered all of the aggregate for one batch of concrete to one of the two Ransome mixers under the platform, which discharged into 1½-yd. bottom-dump Stuebner steel buckets which were set in pairs on 2 coupled cars drawn by one horse on a 600-ft. service track to the main pier caisson, or to the anchor pier, where they were unloaded and emptied by the derricks installed there.

The compressed air, with a maximum pressure of 40 lbs. per sq. in., was delivered to the working chamber of the south caisson through two 12-in. pipes, as stated above, which in turn was distributed into four 7-in. mains.

Water at 100-lb. pressure was distributed around all four sides of the working chamber in a horizontal main from 4 to 6 in. in diameter, provided each of the 18 compartments with a valved outlet and jet pipe with 1-in. nozzle used to loosen the sand and excavate the earth and gravel. Each chamber was also provided with a 6-in. vertical blow-out pipe and with electric lights. The caisson was fitted with six 3-ft. material shafts, each having a Moran air lock with four 3-ft. ladder shafts having simple air-locks composed of short upper sections with top and bottom diaphragms, and with one large man-lock. The latter was a 6-ft. horizontal steel cylinder about 30 ft. long, located on the deck of the caisson, and was built permanently into the solid concrete of the pier, being approached through a 4 x 4-ft. vertical stair shaft. The lock was large enough to accommodate many "sand hogs" at once, thus greatly expediting the entrance and exit of each successive shift, effecting an economy of air consumption and considerably reducing the waste of lock air.

A hospital lock was also established on the shore near the "sand hog" house. Under moderate pressures, 100 men worked 8 hours in each shift. As the pressure increased the lengths of the shifts were diminished to a minimum of 1 hour. As many more sand hogs were required to carry on the work, great difficulty was experienced in securing enough men, so that eventually the number of men in each shift was considerably reduced. Some of the men lived in an adjacent boarding house provided by the contractors, but the majority of them lived in local villages up to five miles distant.

At the present time the contractor is at work pointing the joints in the masonry and cleaning these piers thoroughly by sand blast. There is also some work still to be done on the dressing of the bridge seats. This work is very important and has proved a very difficult operation. These bridge seats are about 32 ft. x 26½ ft. and it is necessary that they should be absolutely level to distribute the load from the main steel pedestal, the base of which is shipped in four pieces. It requires about six weeks to complete the dressing on one of these beds, and it has been found that the work can be done with such accuracy that not more than a variation of 2/100 of an inch is possible.

This work is under the supervision of the Board of Engineers, Quebec Bridge, which is composed of C. N. Monsarrat (chairman and chief engineer), Ralph Modjeski and C. C. Schneider.

RESERVING WATER POWER SITES.

Consistent with the policy of the Dominion government to preserve the water powers for the people, the department of the interior is placing under reservation all vacant Dominion land that the superintendent of water powers may recommend to be valuable for the development of water power, says Conservation.

Six whole sections of land, in township 108, range 6, west of the 5th meridian, have recently been reserved from disposition of any kind until the engineers of the water power branch have had an opportunity to make a complete survey of the famous power site at Vermilion falls, on the Peace River in northern Alberta.

Similar reservations have been made on the various rivers in the provinces of Manitoba, Saskatchewan, Alberta, and in the railway belt of British Columbia. Particular mention might be made of reservations covering land contiguous to Grand Rapids on the Athabasca River, the various power sites on the Elbow and the Bow Rivers, in the province of Alberta; for land required for the development of power at Grand Rapids on the Saskatchewan River, and all unoccupied land along the Winnipeg River, in the province of Manitoba.

Other reservations will be made from time to time upon the receipt of sufficient information to enable the superintendent of water powers to make a definite recommendation covering a description of the land that might be required for power purposes.

PROGRESS AT CEDARS RAPIDS, QUEBEC.

THE Cedars Rapids Manufacturing and Power Co. has under construction an extensive power plant at Cedars Rapids on the St. Lawrence River, about 30 miles west of Montreal. There is a fall of 32 feet and the installation is designed for an output of 160,000 h.p., of which 100,000 h.p. is for immediate consumption. The ultimate consumption will utilize 56,000 ft. per sec.

The development begins with a canal which is being built along the north bank of the St. Lawrence, a distance of 12,000 ft., in which is concentrated the fall of 32 ft. The width of the canal is approximately 1,000 ft. The power house at the lower end of the canal, and forming a portion of the dam, is 663 ft. long and 140 ft. in width. Details with respect to the development, including the power house equipment and general methods of construction were given in an article appearing in January 1st, 1914, issue of *The Canadian Engineer*. The accompanying photographs and data relate particularly to the work which has been accomplished since then.

The south bank of the canal which, when completed, will be practically a straight earth wall two miles in length extending the entire length of the headrace, is progressing rapidly. Water is excluded from the canal by an earth bank serving as a cofferdam. Upon the completion of the canal, this bank will be removed. Fig. 1 shows the work near the upper end of the canal. Excavation is practically completed at this point. The illustration shows, in the south bank, a portion of the spillway and ice sluice. Various portions of the canal between its extremities are down to grade with the bottom more or less clean. For a greater part of the distance the south bank is also practically completed. Fig. 2 shows another portion of the canal and bank, in an advanced stage.

The construction of the power house has reached the stage shown in Figs. 3 and 4. On the north end a single dam will connect temporarily this end of the building with the north bank of the river. It is on the north side that future extensions will be made for the additional 60,000 h.p. at a later date. The south end of the power house will connect with the south bank of the canal. Fig. 3, illustrating the east or downstream side of the power house, shows the draft tubes and the tail race under construction. The latter is being brought down to grade at the present time and a little excavation remains to be done. The work at this portion of the development involves nothing beyond the disposal of excavated material. In the view of the west or upstream side (Fig. 4) every three openings will provide water for one of the 10,800-h.p. water-wheels which are being installed. These wheels are of the single runner vertical shaft type and will operate at 56 r.p.m. under a head of 30 ft. The height of the water will thus reach about midway between the bottom ledge of the large windows and the top of the openings shown in the illustration. The smaller openings in the centre of the building are the intakes for the three 1,500-h.p. exciter units, to operate under the same head at 150 r.p.m. The higher opening in the concrete about the middle of the wall is for the purpose of ice disposal.

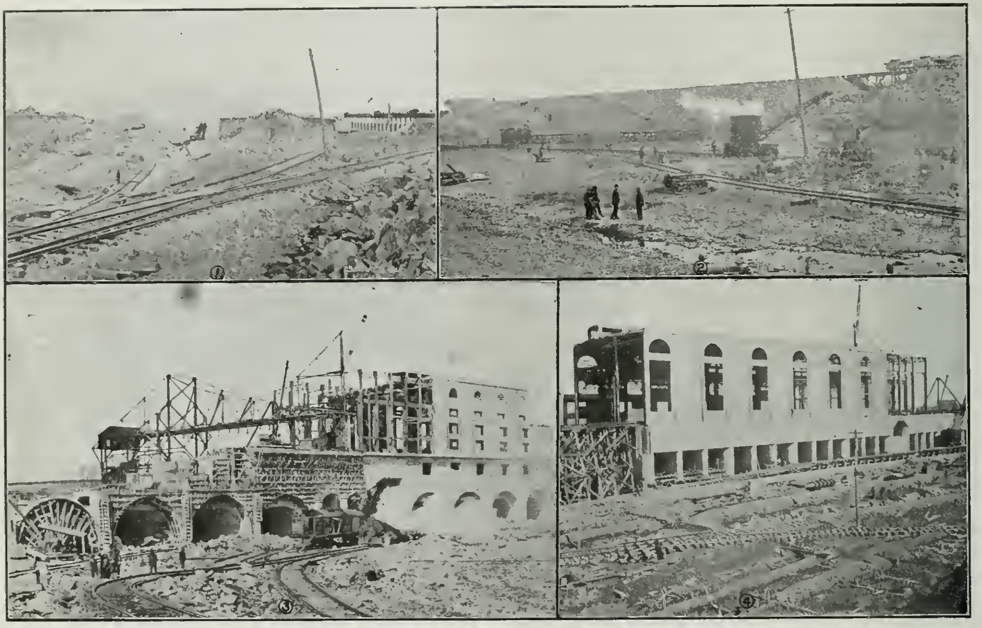


Fig. 1.—Upper end of Canal as it appeared on May 15th, 1914. Fig. 2.—Portion of Canal down to grade and bank almost completed. Fig. 3.—Downstream side of power house, showing manner of construction. Fig. 4.—Upstream side of power house, which will form portion of dam.

The large crane, shown in Fig. 3, is used to convey buckets of concrete from dump cars to the forms. The

rock-crushing, concrete and mixing plant is located considerably to the north of the power house.

Of the views illustrating the interior of the power house, Fig. 5 illustrates the general method of erection and the location of the wheel-pits, which are shown in various stages. The cover plate of a water-wheel, shown in the background, has a diameter of 20 ft., and weighs about 60 tons. Portions of the spiders which are to support the field coils of the generators are also shown near the western wall. In the foreground are some of the guide vanes of the water-wheels. Fig. 6 shows one of the pit-liners being lowered into a wheel-pit, while Fig. 7 illustrates the speed ring of one of the wheels. Fig. 8 shows one of the cover plates which rests immediately over the water-wheel, with a shaft 27 in. in diameter projecting through the shaft chamber shown. Upon this shaft is mounted the generator, supported by a thrust-bearing. Each generator is 37 ft. in diameter.

The transformer house, which is about 800 ft. distance from the present north end of the power house, has been completed as far as the foundations. Concrete is being placed by means of tremie pipes.

The following table illustrates the progress which has been made upon the work and the stage of construction on May 1st, 1914:

	Aug. 23, 1913.	Dec. 1, 1913.	May 1, 1914.
Rock excavation	21%	23%	58%
Earth excavation other than stripping and trench work...	43%	60%	73%
Earth excavation in trenches and ditches, and stripping seats of banks	36%	84%	Complete
Transporting and placing excavated rock	20%	28%	62%
Stone protection	2%	3%	5%
Transporting and placing excavated earth	43%	63%	77%
Concrete in power house substructure	16%	26%	69%

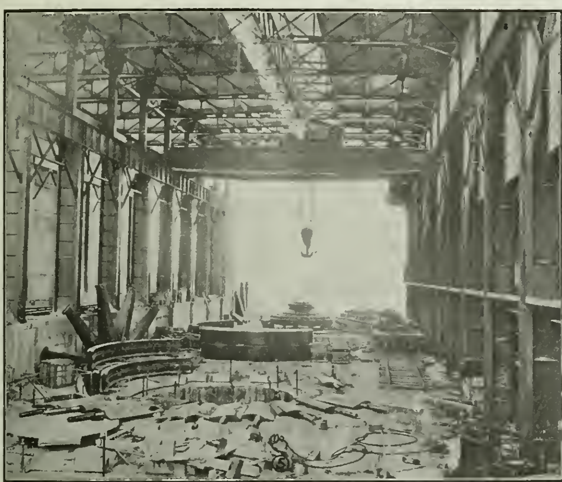


Fig. 5.—Interior view, showing unassembled parts of water-wheel and generator. Fig. 6.—Pit-liner being lowered into position.

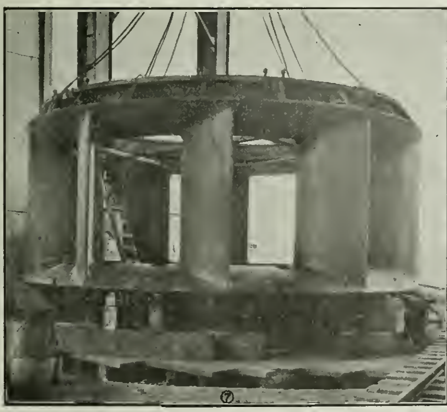


Fig. 7.—Speed-ring of one of the twelve 10,800-h.p. water-wheels (of the single-runner, vertical shaft type). Fig. 8.—Assembling a waterwheel cover-plate.

The Cedars Rapids Manufacturing and Power Company awarded the contracts for the supply and installation of the water turbines to the I. P. Morris Company, Philadelphia, and Wellman-Seaver-Morgan Company, Cleveland. The General Electric Company, Schenectady, N.Y., are supplying the electrical equipment. The structural steel is being supplied by the Phœnix Bridge and Iron Works, Montreal. The power house units and transformer station superstructure are being erected by the Unit Construction Company, St. Louis. Messrs. Fraser, Brace & Company are the general contractors.

CLAY COATING FOR WOOD PIPE.

It is generally known that the durability of wood pipe for water transportation depends largely upon its continuous and perfect saturation with water. In this connection it has been contended that pipes should be thin enough to insure the penetration of water through the pores of the wood, at a more rapid rate than the loss of water by evaporation from its surface. The difference in the porosity of different timbers causes a variation in proper thicknesses.

There are many incidences of the long life of wood pipe. Most of them are accompanied by the fact that the pipe was buried in clay and the whole is an indication of the preservative properties to be found in clay relative to wood pipe laying. Most clay is not a good culture bed for the growth of fungus that causes decay. Further, clay holds moisture and thus insures continuous and thorough saturation of the wood at the surface of the pipe.

In view of this preservative quality of clay "Engineering and Contracting" suggests incasing wooden pipe with clay to the thickness of several inches where the clay is within comparatively easy reach and particularly where the trench is in soil that is either very porous or contains much vegetable humus. It is suggested that a clay jacket around wooden pipe would prove economical. A concrete jacket would be likely to serve a similar purpose, but ordinarily at a greater cost than clay.

The suggestion is one which might well be tried out. Wooden pipe has many advantages for water transportation, and if its liability to rapid decay could be substantially offset the result would be of extreme value.

REPAIRING A STEEL TAPE IN THE FIELD.

In the progress of the day's work there are few more annoying incidences productive of delay to a survey party than the breaking of a steel tape. The process of repairing it by riveting has been superseded by several other methods of greater convenience and rapidity. The outfit required for riveting cannot be carried about so as to be ready for use when the emergency calls for it. The same applies largely to a soldering outfit of sufficient size to be of material use.

A tape repairer that has been found very satisfactory and a splendid time saver consists of a strip of tin about ¾ inches long with two of its edges bent over until they almost meet. The inner faces have a coating of soft solder. To repair a broken tape the fractured ends are inserted, the overlapped edges of the tin forced together by a little hammering and the solder heated by holding a lighted match under the splice.

Two or three of these devices can conveniently be carried in the field and will be found a very useful part of the outfit. They are prepared in different widths to fit any tape. The Chicago Steel Tape Co. are the manufacturers.

There are, of course, new soldering pastes on the market which require no soldering iron or separate flux, a small amount of which, together with a few strips of tin can be conveniently carried about. They are not so convenient, however, and there is less liability of making a strong and satisfactory repair as with the device suggested above.

NEW PROCESS OF RUST PREVENTION.

Making use of the common knowledge that chemically pure iron is practically rustless, a new process has been devised by which steel surfaces are coated with almost pure iron. This process has been termed ferro-zincing or ironizing. In it hydrogen is the chief impurity, the presence of which appears to be advantageous in that the iron coating containing it is slightly more electro-positive to the underlying steel than it would otherwise be.

The coating of electrolytic iron has another advantage, that of being homogeneous, and, according to "Engineering," London, is not under an equal strain caused by mechanical operations, such as drawing or hammering. Further, it has not been subjected to any heat or mechanical treatment, which of necessity causes impurities to be absorbed by the metals so treated.

This process, if commercially applicable, should mark a new era in the use of steel. The preservation of iron and steel from corrosion by galvanizing has been largely used by engineers with considerable success. There are in reality two processes: the first, dipping the iron in molten zinc in combination with suitable fluxes—called hot-galvanizing; and, coating the iron or steel surface by electro-zincing—cold-galvanizing. The reason that zinc, as a protective coating for iron and steel, has held its own so long is that it is electro-positive to the underlying metal. In the presence of moisture, the iron and zinc form a galvanic couple, and as long as there is any zinc remaining in contact with the iron within a given area the zinc corrodes in preference to the iron, thus protecting it.

In the new process it is found advantageous to coat the electrolytic iron surface with zinc, for the reason that a zinc coating with an immediate layer of pure iron hydrogen alloy gives a greatly increased life to the ordinary steel tube or plate.

The inventor of the process, Mr. S. Cowper Coles, Westminster, has arranged with the British Mannesmann Tube Co. for the protection of boiler tubes, and is applying the process to a number of other purposes.

EQUALITY OF WATER FLOW DEPENDENT ON FOREST COVER.

It has been urged that in the interests of navigation the Dominion Government should purchase such denuded forest land in the eastern provinces as might be necessary to reforest in order to prevent floods and the filling up of streams with sediment. In this connection the report on the Trent Watershed Survey, recently published by the Commission of Conservation, is of considerable interest. In this region of Ontario, as a result of fires, 150,000 acres are practically a desert and the report urges a policy of forest conservation under Dominion, provincial or municipal control, in order to preserve the usefulness of the Trent Valley Canal, in which over $10,000,000 are invested. There are many such barren areas in the eastern provinces, which with the assistance of the Dominion Government might be made to produce valuable forest crops.

In Canada disastrous floods and low-water stages have been largely prevented by the timely action of the Dominion Government in setting aside as forest reserves the wooded slops where the great rivers of the interior of the Dominion have their origin. On the east slope of the Rocky Mountains over 20,896 square miles of non-agricultural land have been thus reserved, for the double purpose of regulating the run-off and of providing a perpetual supply of timber to meet the ever-increasing needs of the prairie settlers. In the Railway Belt in British Columbia smaller reserves have also been set aside, chiefly for the purpose of maintaining a steady flow in the streams on which the fruit-growing industry is absolutely dependent.

STEAM RAILWAY ELECTRIFICATION.

THE factors entering into the selection of a system when contemplating the electrification of a steam railway were ably discussed in a paper read by Mr. J. A. Shaw, of the Canadian Pacific Railway Company, at the 24th annual convention of the Canadian Electrical Association, held last week in Montreal. The importance of choosing a system suitable for general conditions, to permit interchangeability of rolling stock between different sections, and to allow extensions to be made as economical and reliable operation, or other conditions warrant, were properly emphasized. We reproduce the following from Mr. Shaw's paper:—

Three systems now exist which include all which need be considered in view of the present state of electrical development. One, the three-phase alternating, is not suitable for general electrification, on account of requiring two trolley wires, with the resulting complications and the peculiar characteristics of the motors employed. The remaining systems are single-phase alternating current, and the 2,400-volt direct current.

The single-phase system has been used in the electrification of the New York, New Haven and Hartford Railway from New York to Stamford, and is now being considerably extended. It has also been used on a number of light railways, notably the Spokane and Inland. Abroad it is in use on the London, Brighton and South Coast Railway, the Swedish State Railway and others, and has been adopted by the German, Swiss and Austrian State Railways as their approved system, although it cannot as yet be considered as completely through the experimental stage.

The 2,400-volt d.c. system is a development from the 600-volt system, which is practically the standard in all street railway and interurban work, and which has been so successful on that field. The electrification of the New York Terminals of the New York Central and the Pennsylvania lines, the Atlantic City Line of the Pennsylvania, the New York Subway, and all elevated railways have also employed this system. Abroad it has been used on the Lancashire and Yorkshire Ry., and in general under conditions similar to those in this country. During the past three years a number of light railways have been installed using 1,200-volt d.c., in most cases, however, using 600-volt motors, and from the experience obtained, the 2-400-volt system has been developed, using 1,200-volt motors, and this system has now been in use on the Butte, Anaconda and Pacific Ry., preparatory to a further use of it on two divisions of the Chicago, Milwaukee and Puget Sound Ry., for the past 10 months. A lower voltage installation at 1,500 volts has been in service over three years on the Piedmont Ry. in South Carolina.

Supply of Power.—It is possible that in the majority of cases for years to come that power will be generated for locomotive purposes alone, without considering its use for other purposes. However, electrification will be made possible more through cheap power being available from existing power plants, where if a separate plant had to be erected it would be too expensive. Possibly in the future power plants will be constructed at points where commercial power is not available, but even in that case at other points on adjoining divisions commercial power might be obtained, and to permit of uniform equipment the power generated would either have to be uniform with that purchased or the latter converted to the character required. Throughout the West and in the Montreal district, 60-cycle, 3-phase transmission is practically universal, and, while 25-cycle, 3-phase current is employed on the Hydro-Electric and Toronto-Niagara transmissions from which 25-cycle single-phase could be obtained by stationary transformers, balancing apparatus would be required. In view of the tendency to use 15-cycle in place of 25-cycle current in single-phase electrification and the remoteness of general electrification in Ontario, it is reasonably safe to assume that converting apparatus will be required for either single-phase or direct-current installation. The application of 15-cycle generators in 60-cycle power stations or of frequency changing apparatus to furnish single-phase current, while possible, does not actually change this assumption, as the increased price asked for by the power companies equals the cost of conversion by the railroad in addition to requiring the erection of separate transmission lines.

The general arrangement of the two systems is outlined in Table I.

TABLE I.

Single Phase.	Direct Current.
A 1. Power line of supply company.	D 1. Power line of supply company.
A 2. Conversion station at one or two points per division furnishing single-phase current from motor-generator apparatus and step-up transformer for raising potential. If power lines are available at several points on division, number of conversion stations may be increased, and length of transmission lines correspondingly reduced.	D 2. Transmission line to sub-stations. Where supply company power lines are available at several points on division, sub-stations may be conveniently located at such points, and length of transmission line correspondingly reduced.
	D 3. Sub-stations in which three-phase power is converted to direct current by motor generator apparatus.
A 3. Transmission line from conversion stations to transformer stations.	D 4. Feeder line by which direct current is supplied to trolley line.
A 4. Transformer station in which high voltage single-phase current is transformed to 11,000 volts for trolley line.	D 5. Trolley line and bonding.
A 5. Trolley line and bonding.	D 6. Electric locomotives or motor cars.
A 6. Electric locomotives or motor cars.	

Cost of Installation.—An inspection of above table shows that as a general proposition certain of the items are practically common to both systems. Transmission lines A-3 and D-2 will be required for the entire length of the division if power were received at one point: whereas if power were received at several points, while several single-phase conversion stations could be installed, that would not prove practically economical, and with direct current there would be a saving in the transmission line required. The transmission line for single-phase current costs 20 per cent. more per mile than that for 3-phase, so that it is entirely fair to the single-phase to consider the cost of transmission lines equal.

The trolley line and bonding are practically the same. For single-phase, higher insulation is required on account of the higher voltage and the surging which occurs. With the improvements that have been made in the manufacture of insulators, the difference would not exceed 10 per cent. of the cost of the trolley line.

The conversion stations and transformer stations A-2 and A-4 for single-phase will correspond to the sub-stations D-3 for direct current. For heavy traction work on the Chicago, Milwaukee and St. Paul Ry., where it is proposed to handle 1,600 tons on 1 per cent. grades, the sub-stations will be located from 18 to 24 miles apart, the feeder being 1,000,000 cm. Considering a direct

current section having sub-stations 20 miles apart, the distance between transformer stations for single-phase current will depend on the worst conditions that should be permitted to occur. Thus with the direct current with a voltage drop of 50 per cent. trains could be handled at one-half speed with full tractive power. With single-phase the maximum drop permitting this condition would be from 20 to 30 per cent. The latter figure will be taken as most favorable to single phase, and the distance apart of stations calculated: 1st, when the number of trains on a section is proportional to its length; 2nd, when the same number of trains are concentrated at the centre of a section irrespective of its length. The spacing of the stations can also be calculated when the efficiency is the same for both systems, the number of trains per mile of track being the same. The results are as follows:—

Limiting operating conditions, trains uniformly distributed or number proportioned to length of section .... 30 miles.
Limiting operating conditions, same number of trains at centre of section........... 45 miles.
Equal efficiency, number of trains proportioned to length of section .... 30 miles.

The limiting operating condition with the number of trains proportioned to the length of the section is evidently most important from a general railroad standpoint, and transformer stations, say, 33 1-3 miles apart, would apparently give substantially equal service compared with direct-current sub-stations 20 miles apart. The total capacity of the direct-current sub-station will exceed that required in the conversion station, since each sub-station must be able to carry the load of the trains that may be starting in its vicinity. The total cost of the single-phase stations is, however, increased by that of the transformer stations, which cost one-third as much per kilowatt capacity as the conversion or sub-stations. The two systems are thus equal in cost when the sub-station capacity with direct current is 44 per cent. greater than the conversion station for single-phase. In some cases the difference is not sufficient, but lines will not be electrified on which traffic is insufficient to render the load reasonably uniform. As in the case of the transmission line and trolley the single-phase was more expensive; in this case the direct current will be in general slightly higher—the net results being very closely the same.

The remaining items are: A-6 the single-phase locomotives, D-4 the d.c. feeder, and D-6 the d.c. locomotives. The feeder proposed is of 788,000 cm. area, costing at 18 cents per lb., $2,250 per mile, or $2,500 per mile erected. The cost of the locomotives will vary according to the type and capacity, but based on d.c. locomotives costing $40,000, those for single-phase current will cost $60,000, so that if one locomotive is used for each eight miles of track, the total cost of the two items is again substantially equal.

The net result is that where power is obtained from 3-phase distribution, the cost of electrification by single-phase or d.c. is substantially the same. This is confirmed by several careful independent estimates. With direct current the expenditure on feeder copper and sub-station apparatus is balanced by the slightly increased cost of the trolley and transmission line for single-phase current and the much greater cost of the locomotives.

Cost of Operation.—Cost of operation is affected by the efficiency of the system, the cost of operation of the sub-stations and the cost of the maintenance of the locomotives and other apparatus.

The efficiency of the system will determine the cost of the power supplied, and, if the movement of the trains and the power they each consume is known, could be calculated with considerable accuracy. When power is purchased, especially water-power, the cost depends on the peak load during certain hours, and trains will be operated to reduce this as much as possible. It is, therefore, difficult to forecast the train distribution. There is, however, no general evidence to show that greater efficiency may be obtained with single-phase than with direct-current equipment. Several records of actual service show that with direct-current under similar conditions the results are more economical than single phase. This is especially so when the power per car mile is considered on account of the greater weight of the single-phase equipment. From what we have already learned and figures published, it may be safely assumed that on any section of a railway on which there is sufficient traffic to justify electrification, the power required by direct current will not exceed that required for single phase.

The cost of sub-station maintenance and operation is greater for direct current. On a 100-mile division there would probably be five (5) sub-stations, each containing moving apparatus which requires attention as against one for single-phase system. Each of these sub-stations would cost from $3,000 to $4,000 per year, or, say, $18,000 per annum, against $4,000 for the single-phase station. It is doubtful whether the wages cost of $2,000 per year per station, or $10,000, is a proper charge against the direct current. On main line work it will be absolutely necessary to arrange to cut out any portion of the road on which accidents may occur, and for this purpose attendance will be required. Trains must be moved away from any section temporarily disabled to prevent congestion, and of the $14,000 additional cost it would appear entirely fair to estimate that about $8,000 is the most that would be entailed by the sub-stations. This is more than equalized by the greater cost of maintenance of the single-phase locomotive. Direct-current locomotives are being maintained for 3¼ cents per mile, of which 2 cents is entirely separate from the electric motor, control, etc. On the single-phase locomotives, the cost has been higher, but it is hoped to reduce it to between 5 and 6 cents. For short distances the direct-current locomotives as used out of New York will handle a train that requires two single-phase, and if this were allowed for, the difference would be very great. The new switching and freight locomotives on the New Haven, it is stated, have been maintained for a comparatively low figure, but they have as yet not been in service sufficiently long to give a final value. The construction of all single-phase locomotives is far less sturdy than that of direct current, on account of the difficulty of keeping the weight down to a reasonable amount, and the construction is far more complicated. It cannot be expected, therefore, that they can be maintained for a lower percentage of their total cost. A fair difference to assume is that cost cannot be taken at less than 2 cents per mile for locomotives of equal power, say, 1,000-h.p. each. Considering a division with 1,000,000 miles per year, or $20,000 at this figure, so that the cost of operation and maintenance of sub-stations is more than taken care of by the increased cost of maintenance of equipment. The single-phase locomotive is also considerably heavier than the direct-current for equal power, and this is especially true when motor car equipment is considered. This increase in weight means a correspondingly reduced train load, unimportant on level districts, but of appreciable amount on heavy grades. It also entails an additional expense for power which is serious in light passenger or motor car service. There is, of course, a possibility that 2,400-volt d.c. apparatus will cost more to maintain than 600 or 1,200-volt, but there does not

appear to be any reason to fear its becoming excessive. While there is no doubt that the New Haven have had more electrical trouble than the New York Central and the cost of repairs has been higher, due to the mechanical construction of the locomotives rather than to the electrical equipment. This mechanical construction is, however, necessitated by the use of the single-phase motor. While there is no reason why the same construction should not be employed with the 2,400-volt d.c. system as with the 600-volt. In general, there is no reason to expect the cost of operation with the single-phase system to be less than that with the direct current.

Possible Difficulties with 2,400 Volts.—The above discussion considers that 2,400-volt d.c. will prove equally satisfactory as 600 or 1,200-volt installations. In a system that has not been thoroughly demonstrated in practical service, there are some features from which trouble may be experienced, and these are discussed as follows:—

The simple and strong design of the d.c. locomotive is partly due to the use of geared locomotives for freight service and gearless for passenger service. The construction which has been adopted and which is practically necessary for single-phase locomotives of any size, supports the motor entirely independent of the wheels, the latter being driven through springs or connecting rods, thus reducing the dead weight to that of the wheels and axles alone, while retaining the same total weight on each wheel. The centre of gravity of the locomotive is also raised to a point approximating that general for steam locomotives. From experiments conducted on engine and tender trucks and the experience of maintaining track under various types of locomotives, it is safe to assume that the dead weight of 9,000 to 10,000 lbs. per axle on gearless locomotives and the slightly greater weight on geared, does not, for the services in which they will be respectively used, appear likely to affect the cost of track maintenance sufficiently to justify the additional expense and complication involved in reducing it. In view of the greater total weight of the single-phase locomotive it is very doubtful whether its effect on the track will not be greater than the direct-current locomotive, even though the dead weight per axle is higher in the latter. Increasing the height of the centre of gravity reduces the lateral shocks on the rail, but this action is caused by these shocks in steam locomotive design being absorbed by the vertical movement of the springs. It will be unfortunate if electric locomotive design cannot be developed in which these shocks are absorbed by springs, or frictional methods of restraint, so that the simplicity which should accompany the application of motors to drive the wheels of a locomotive may be retained; there is no reason to doubt this being accomplished. Should it prove impossible, the direct-current locomotives would become more complicated and approach the single-phase more closely in cost, the difference being probably 25 per cent. in place of 50 per cent.

The question of current collection at 2,400 volts at high speed has been experimented with, but not fully demonstrated as yet in service. It has been found practical to collect 200 amperes at 60 miles per hour from one roller trolley without injurious sparking, which at 2,400 volts equals 480 kw. Two trolleys can be located 20 feet apart, thus permitting 960 kw. on one locomotive. This question is important, but there seems little question of its being solved satisfactorily. The control of 2,400-volt current does not appear to present any difficulty. Contractors will be arranged to break the current in series, and from results in operation there seems no reason to anticipate any more trouble with 2,400 volts than with 600. Maintenance of motors may be higher with 2,400 volts than with 600 volts. The motors will, however, operate under 1,200 volts each, and the fields in both motors will practically be at ground potential. Twelve hundred volt motors have operated interurban work for five years without indicating any increased cost on maintenance, and while this has been in a dry climate, the forced ventilation to be employed in railway work will give very closely the same condition. The 2,400-volt motor will have the same capacity to stand heavy starting load, the same freedom from commutation trouble, and in general the same ability to stand the severe service imposed upon it by locomotive or traction work that the 600-volt motor has been proved to possess.

The operation of fan and compressor motors on high voltage has to be properly worked out. There are no doubt some difficulties in this respect, but they should certainly be overcome by experience.

Comparison of Systems.—It has been shown that on the assumption that the 2,400 d.c. and the 11,000-volt single-phase a.c. system each operate as satisfactorily as their advocates claim, that there is comparatively little difference in their cost of installation and operation. Each is equally flexible, each will operate and in all probability give a high degree of satisfaction compared to steam locomotives. The principal difference is that, with the direct current a larger portion of the cost of installation is in feeder copper and conversion apparatus, and less in the locomotives, and a larger portion of the cost of operation is in the sub-stations, attendance and maintenance in place of locomotive maintenance. This of itself should prove decidedly to the advantage of the direct-current system, as the sub-station apparatus is stationary and can be carefully maintained, and the simpler and cheaper the locomotive the less danger there will be of a breakdown. In addition, the investment in copper is permanent, while that in locomotives may rapidly depreciate with any new developments. There are, in addition, some minor points worth attention which may be referred to.

The regulation of speed on the single-phase system is in many ways preferable to that on the direct current. By drawing current from the transformer at the voltage suitable to the speed and power required, all speeds are equally efficient, and the use of resistance in the circuit is avoided. This is an exceedingly ingenious method, but it is doubtful whether it is of great practical importance. While the direct-current motors have only two full-power efficient speeds, decreased power can be obtained at higher speeds than either of them by field control with very small loss in efficiency. This would apply particularly in passenger service, since in freight service the characteristics of the motor are such that it would not be required. The use of a transformer on the single-phase locomotive permits the operation of the motors at low voltages, and on ungrounded circuits. There seems, however, no reason to fear the use of high voltage on the direct-current motors, or danger, providing it is properly insulated. There has certainly been more trouble on the single phase from grounds than on the direct current, and it appears to be entirely a question of proper insulation. The relation between the speed of the motor and the power it will develop is different for single phase and direct current. Taking two motors which will develop the same power at a given speed, the direct current will develop greater power at lower speeds and less power at higher speeds than the single-phase motor. This is the reason for the success of the direct-current motor in traction service. It can exert a greater pull without injury and is less liable to damage from overheating when starting a heavy load than any other type of motor. It is also this feature which makes the gearless locomo-

tive a possibility for passenger service, as it enables a motor of reasonable size to start a passenger train without the use of gearing to furnish the necessary power. Direct-current motors can certainly be constructed to handle passenger trains at high speed if desired, so that in this respect the advantage is greatly in its favor. The direct-current motor has obtained its reputation for ruggedness from its capacity to withstand heavy loading without injury, and this quality is of the greatest importance in railroad work.

Conclusion.—If in place of discussing the relative advantage of single-phase and direct-current traction, the start is made from the direct-current system with its simple and strong electrical apparatus developed after years of experience by simply an increase of voltage, and assuming that this increase does not lead to unforeseen difficulties, the question becomes, What is gained by the use of single-phase current?

It does not save in cost of installation or operation.

Its application is not more flexible.

It introduces a locomotive that is more complicated, in which the motor is necessarily far more expensive and elaborately constructed, and which weighs considerably more than one for direct current.

It reduces cost of sub-station attendance at the expense of locomotive maintenance, and consequent reduction in reliability.

The general advantages to be gained by electrification are too well known to bear repetition, but it might be mentioned from the data now becoming available from those installations now in operation that results obtained confirm estimates very closely. The engineers of the Chicago, Milwaukee and St. Paul Ry. estimate that at least a saving of 25 per cent. will be made in operating costs on the 440-mile division now to be electrified in the Western States, and part of this saving is confirmed by the showing already on the Butte, Anaconda and Pacific Ry., where power cost has been found to be but one-third of the previous coal cost. The decision to electrify the suburban lines of the Pennsylvania Ry. about Philadelphia was made to relieve the existing congestion by increasing the capacity of terminal 15 to 20 per cent., or sufficient to relieve the situation for the next five or six years and at less expense than any other method.

PROGRESS OF NEW GANGES BRIDGE.

The largest steel bridge ever made for shipment from England is rapidly nearing completion. Six spans are being constructed by an engineering firm at West Bromwich, and the remaining nine at Darlington. This bridge will carry the Indian State Railway over the Ganges at a point about 120 miles above Calcutta, and it will be just a mile in length.

Steel to the quantity of 30,000 tons (all rolled in England) is being employed in its construction, 20,000 tons for the superstructure, and 10,000 tons for the piers. Each of the sections has a span of 345 feet, a height of 49 feet, and a weight of 1,400 tons. To hold the sections in position steel caissons were sunk 150 feet below the bed of the river. The shipment of these 15 spans to India will entail an outlay of some $300,000, and the total cost of the bridge will be $6,250,000. The erection of the bridge is under the direction of the Public Works Department of India. The first span shipped from West Bromwich arrived at Calcutta on May 26 last, and it was erected in three weeks' time before the rainy season, with its river floods, sets in. It is hoped that this bridge will be open to traffic this year.

A gigantic floating dock, said to be the largest in the world, is being constructed at Odessa. It will be capable of carrying a vessel of 40,000 tons, and will cost $2,000,000.

SOME PRACTICAL POINTS ON MODERN ROAD-WORK.*

By W. H. Maxwell, A.M.I.C.E.

In the planning of new through routes, directness of line is usually an important feature to be considered, from an engineering and utilitarian point of view, but leads to monotony in the use of the road, and from an æsthetic standpoint compares unfavorably with winding roads.

As a general rule, it will be more advantageous to carry a new through route past the outskirts of a town, and connect up with some good branch road to the urban area, rather than attempt to carry the new main thoroughfare through the heart of a populated centre, as the difficulties and costs of widening existing narrow roads through built-up areas are necessarily excessive, owing to the property and business interests disturbed. Very wide roads are not favored by shopkeepers, as they are not conducive to good trade—the bulk of pedestrian traffic usually keeping to one side of such a road.

Curves on a new main road should, of course, be as easy as circumstances will permit, but a radius of 100 ft. should be the minimum where fast through traffic is to be accommodated. On this curve, a person travelling along the centre line of a clear 40-ft. roadway could see approaching traffic within the limits of the road-width about 120 ft. ahead. Under similar conditions, with a 150-ft. curve, a distance of about 150 ft. ahead could be seen. On rural roads, traffic invariably uses the centre of the road by preference, and modern high speeds render an ample, unobstructed view essential.

The easing of curves invariably quickens the speed and reduces that degree of commendable caution in drivers which formerly existed. On a sharp curve the motorist is bound to materially reduce his speed or perish.

Curves should in all cases be freed from side sight-blocking obstructions, and for increased safety to fast traffic, the road surface on the outside curve should be given a suitable degree of super-elevation.

On a part of the Holyhead road on the north of the city of Coventry, Telford adopted a ruling or maximum longitudinal gradient of 1 in 35. Such a moderate gradient will present no impediment to fast driving, either up-hill or down, and in one on which tar-macadam and all modern methods of surfacing may be used with safety, but in hilly country will be difficult to maintain, except by much contouring and consequent increased length of route, or by heavy cutting and bridge work.

Dead-level roads are to be avoided. If the longitudinal inclination is less than about 1 in 100, the surface water will be difficult to drain away and more cross camber must be provided. With a longitudinal gradient of 1 in 50, or sharper, the camber may be flattened considerably, as the needful surface drainage is obtained longitudinally. This flattening of cross-section should not, however, be carried too far, otherwise watercourses will speedily form down the centre of the roadway on steep gradients.

Suitable cambers for different surfaces under ordinary conditions are: granite macadam, 1 in 25; tar-macadam, 1 in 30 or 1 in 40 on incline; creosoted deal paving, 1 in 36; hard wood and granite, 1 in 45; and asphalt paving,

*A paper read at the 41st Annual General Meeting and Conference of the Institution of Municipal and County Engineers, held at Cheltenham, June 24th-27th, 1914.

1 in 50. The longitudinal fall of water channels should not be less than 1 in 100 for a granite channel, and 1 in 150 for asphalt.

Improvement of Existing Roads.—Inadequate Foundations.—The majority of the old highways of this country have come into existence in a more or less haphazard fashion, and in the past the provision made for their maintenance has been uncertain and inadequate. The entire absence of foundations suitable for carrying modern weights brought upon the surface is revealed by the upward movement of the sides of the roadway into the channels—a weakness to be observed generally throughout the country.

Vast sums are now being spent in laying down expensive so-called waterproof surface crusts of various kinds, in order to give an immediate show for the money expended, but the writer is of opinion that, wherever there is evidence of underlying weakness, money may be more advantageously applied by first putting in proper foundations and drainage. However excellent, well laid or expensive may be the surfacing material, it can never prove really satisfactory on a weak foundation. There will be gradual but constant movement of the road crust, local sinkages of the central portion and rising of the sides, and generally the annual expense of wear and tear of the surface will be greatly enhanced in cases where no solid and unyielding foundation exists.

The initial cost of such work is, of course, necessarily heavy, but where suitable foundations do not already exist, it is submitted that it is the only sound course to pursue, both from an engineering and financial point of view, and is essentially a capital work for which State "grants" on liberal terms should be made.

Thin Crusts.—The wisdom of recent practice in laying thin surface wearing crusts or armourings of asphalt and bituminous preparations over existing macadam surfaces is open to great question, except where an absolutely rigid and dry foundation can be relied upon. In the absence of this, most ordinary road surfaces are subjected to consider movement under modern speeds and weights, and in these circumstances, thin wearing crusts are liable to fracture and disintegrate. Great caution in the selection of a suitable site is necessary, except where laid on a good concrete foundation, which, unfortunately in most cases, would make the cost of the work prohibitive.

Bituminous Methods.—In what are now known under the general name of "bituminous methods," the presence of coal-tar and pitch is the distinguishing feature, and the main object of all such processes is to exclude water from the crust of the road. These methods consist mainly in the revival and extended use of "tar-macadam," "pitch-grouting," "tar binders," and other like forms, and in suitable situations and conditions give very serviceable surfaces at a not unreasonable cost, but much discrimination is needed in their application.

The arch enemy of the tar-macadam road is the traction engine, and this cumbersome vexatious contrivance is, unfortunately, rather in evidence in the writer's district, especially during the spring and early summer months. These engines, with destructive diagonal steel strips on the wheels, weigh over 16 tons on the road, and haul three lumbering wagons weighing about 12 tons each when loaded. Under this burden the very best of tar-macadam work suffers substantial damage. Even after having been laid many months the material, owing to its plastic nature, will slightly soften on a hot day, sufficient to permit of its being crushed out of shape and torn up under traffic of the class named.

A well-made granite macadam road surface withstands this class of traffic very much better than tar-macadam, or any of the bituminous processes.

To the enthusiast for tar-macadam, in addition to the above caution, the writer suggests that consideration of the following points will help to keep him out of trouble:

1. The quality of tar available for such work is very variable and unreliable, and requires constant watching to avoid failure.

2. Good fine weather is an important factor for successful work. If the weather is too cold there is great risk of too much tar being used, thus causing the tar-macadam to become very soft and easily damaged during the warm weather.

3. Tar-macadam is hopeless on a weak, yielding foundation.

4. It cannot be satisfactorily repaired during wet, cold weather. This is important in streets where much opening of trenches for gas, water, electric and other services is likely to be required.

5. Where there is much traffic a continual watch must be kept on the work for some time after it has been completed, which considerably adds to its cost.

6. Tar-macadam is liable to "creep" during hot weather towards the sides of the roads, especially in country districts, where the lateral support of a curb and footpath is not usually available, and some provision to meet this tendency should be made.

7. The cost of tar-macadam is, as a rule, much beyond that of a granite macadam tar-painted surface, and its serviceable life cannot always be so accurately predicted.

The foregoing matters are mentioned, not with any desire to discourage the use of this type of road surface, but simply with the object of drawing attention to a few points which require consideration to ensure successful work.

With regard to the "pitch-grouting" of road macadam, the writer is of opinion that this process has not yet been proved to be so satisfactory under like conditions of traffic, as good class tar-macadam well laid. The work is expensive, its serviceable life is not great, the surface soon becomes deeply corrugated and carries much slippery mud during wet weather.

Coatings of tar-macadam of a total thickness of 4½ inches are sometimes laid with a layer of coarse material at the bottom, and finished with a fine grade for the surface. A coating of the thickness named is best laid in two layers, but there is no advantage in separating the fine and coarse grades; the same mixed grade material should be used for both coats.

Rolling of tar-macadam is best done with a "light" steam roller (6 or 7 ton weight), and there is nothing to be gained by an excessive amount of rolling.

Tar-macadam may be laid on gradients as steep as about 1 in 25, and even sharper if the surface is kept clean. The degree of slipperiness experienced depends greatly on the weather and the skill of the driver.

It is a great mistake to lay tar-macadam, or any other bituminous road surface, over an existing macadam roadway as a foundation, without first lightly scarifying the surface all over and consolidating by rolling to a *uniform* condition before the bituminous material is laid. Where this precaution has been neglected the old inequalities and "pot-holes" in the road crust will soon re-appear on the surface of the newly laid coat, as the greater depth of bituminous material over the "pot-hole" consolidates more than the thinner coating around.

Tar and Tar-painting.—Experience of recent years has led to the settling down of much preliminary clamor about "dust-layers" to the very general use of coal-tar. This new demand has brought about a very substantial increase in the price of tar, and, with the continued extension of bituminous methods of road construction, the demand appears likely to exceed the supply, and so set a limit on this form of road improvement unless competitive processes are adopted.

The specially prepared tar for road surface painting used by the writer weighs 12.95 lbs. per gallon, or 173 gallons to the ton. This is heavier than the weights recommended in the Road Board Specifications, but the tar is found to make very satisfactory work.

Tar-painting is not usually very successful on roads with damp clayey sub-soils, in shady situations, or under trees. A dry sandy or chalky sub-soil is the most favorable for the work, and in these areas operations can be started earlier in the season.

The heavy, complicated, costly tarring machines of early tar-painting days have almost disappeared in favor of much simpler plant, and hand work—the latter giving the best results in this class of work.

For town work granite chippings ⅜ in. to ⅝ in. gauge make the best class of "grit" for covering the tar. Sand, though usually much cheaper, produces an increased quantity of mud and causes the tar-painting to tear up more readily under heavy traffic.

In the author's experience the amount of money spent on road tarring is about equivalent to the saving obtained in ordinary maintenance and wear and tear on the roadways, so that no increase on the total cost of highways arises, whilst a greatly improved surface is obtained during the summer and autumn months. Tar-painting gives most economical results on secondary roads, *culs de sac*, and other thoroughfares with light traffic, as, in such cases, the tarred surface remains in good condition for several years without repair, and very little attention of any kind is needed.

Repairs.—Systematic inspection of the roadways, and regular and prompt patching of depressions and "potholes" is very desirable, especially on motor omnibus routes. For this work the writer uses a light roller of the convertible tractor type, which is well adapted for the purpose.

Under modern traffic conditions the highways require to be regularly patrolled and repaired, much in the same way as a railway track.

Old screened road metal, of small gauge, is well suited for patching, as it consolidates quickly.

Ordinary macadam surfaces should not be patched with tar-macadam as, after a little wear, a most unsightly and intolerably bumpy surface results, owing to want of uniformity in wear of the variegated surface.

When recoating a roadway, the thoroughfare should be closed wherever possible, and the whole width of road coated and rolled in one operation. Work of this class done in half-widths is seldom satisfactory, as rapid wear invariably occurs at the central joint. In cases where this system cannot be avoided it is best, if possible, to first treat about two-thirds of the width, so as to keep the joint out of the centre of the road; but many roadways are too narrow to permit of this being done.

Weather conditions are among the most powerful factors influencing the wear and tear and deterioration of roads. Prolonged rain, and heavy traffic following the break-up of frost immediately succeeding a wet period are particularly destructive.

In town streets where a macadam surface has to be renewed about every two years, and patched frequently, a wood-paved surface will probably be more advantageous. A maintenance cost of 20c. per sq. yd. per annum is about the economical limit for macadam, and, from the point of view of traffic weight, a load of some 250 tons per yd. of width per day is about the maximum for an ordinary macadam surface.

Steam Rollers.—In the opinion of the writer the usual so-called "10-ton" steam roller is much too heavy for the majority of surface recoating work. These rollers, when loaded ready for the road, often weigh nearer 13 to 14 tons than 10, and frequently cause much damage to the new metalling by crushing and weakening it during the process of consolidation. In some cases metal is put on the hard crust of the old road, without preliminary scarifying, and rolled down with a heavy steam roller, with the result that the stone, being severely crushed between hard surfaces, is permanently damaged at the outset, and the serviceable life of the new coat thus sadly reduced.

For much of his work the writer uses what is described by the makers as a 7-ton roller, of the convertible roller-tractor type already referred to. This machine is found to be of the greatest service for all classes of work as well as for haulage. The small tractor-roller can be moved quickly from job to job, and can be converted to a tractor in about a couple of hours. This roller, with awning, water, etc., fitted up ready for work on the roads actually weighs 9.42 tons.

Mechanical Haulage for Municipal Work.—Whatever may be the views held as to the desirability of public highway authorities employing steam, petrol, or other motor vehicles for haulage purposes, the writer has been practically compelled to do so, on account of the difficulty experienced, during the busy spring and summer seasons, in procuring sufficient suitable horses. It is usually impracticable to keep, during the relatively quieter winter months, a full stud of horses sufficient to cope with all work during the busier period of the year, and such work as street-watering and road tar-painting greatly accentuates the variation between winter and summer haulage demands. The hiring of the surplus summer requirements affords one way out where the horses can be got, but horse contractors are fast changing to mechanical haulage, thus greatly limiting the supply.

Slippery Road Surfaces.—In these days of improved road surfaces, tar-painting, tar-macadam and such like, complaints are perhaps a little more frequent in respect of slipperiness, and requests for "gritting" or sanding are often made. The best plan to overcome slipperiness is to keep the surface as *clean* as possible, by removing (and washing off if necessary) stiff pasty mud which is liable to accumulate during the foggy, damp weather of the winter months. Gritting and sanding greatly increases the production of this stiff slippery mud, as the material is speedily crushed by the traffic. The application of grit, therefore, should be done as sparingly as possible, and cleansing of the surface should take its place.

Road Signs.—Generally speaking, there is room for improvement in road direction signs. Frequently they are so placed that an approaching traveller cannot read the sign without stopping, and even sometimes dismounting. The direction arm should be at the most favorable angle, the letters not less than 3 in. in depth, and the mileage stated in bold block figures to the nearest quarter. Strangers motoring long distances often find it impossible to quickly gather the name of the place they are passing through, and it would be a great convenience to have the name of the village or town boldly erected on the through

roads near the commencement of the village buildings.

Street corner "mirrors" are costly to erect and maintain, and the moving reflected image is liable to mislead a motorist unaccustomed to them.

It is a mistake to multiply danger and caution signs unnecessarily. They should be confined to the most awkward spots, and be erected by a public authority. No private signs should appear on a public highway. If too numerous, the familiarity of their appearance leads to a general neglect of the warning intended to be conveyed.

Statistics of Traffic.—The expression of traffic records in tons per yard width of roadway does not, in many cases, give a true representation of the amount of wear and tear over a roadway. On roads through rural districts with a comparatively small amount of traffic, a very large percentage of vehicles keep to the centre of the road—in fact, the less the volume of traffic the higher will be the proportion using the centre of the roadway. Thus the sides suffer but little wear, whilst the centres soon become worn out. The average traffic record per yard width does not therefore correctly show the conditions which obtain and a minimum and maximum record is necessary to convey the true facts.

Much the same thing often occurs on very wide roads, as a portion of the width only is used by a high percentage of the traffic.

On busy town roads of medium width the traffic is very fairly distributed, and it is mainly to this class of road that the average tonnage per yard has any reliable significance.

On some roads, owing to the nature of local industries, the *night* traffic is quite an important item, and should not be omitted if a true record of actual conditions is to be obtained.

The collection of information and statistics, in reference to roads, traffic, materials, and other like matters, is a useful occupation from many points of view so far as it goes, but the road engineer should be cautious as to the conclusions he may safely draw from the collected data placed before him. So much depends on the actual conditions in any given case, and it does not by any means follow that because a road material has proved satisfactory or otherwise in one place it will necessarily do so in another. A new set of conditions will produce its own set of results, and the engineer must use his judgment in each case according to his local knowledge and experience.

Experiments and Tests.—Laboratory and other indoor tests of road materials serve a useful purpose in arriving at the physical and chemical properties of the materials, and assist the engineer when the information so derived is seasoned and matured by practical experience on the road. Weather and traffic are of paramount importance in all road-making matters, and there is no test to be relied upon other than that of actual and adequate trial on the road under ordinary conditions of traffic, rain, frost, and numerous other distributing influences to which any road material must necessarily be subjected.

Administration of Highway Maintenance.—Good administration, particularly in reference to the disposition of labor, materials, and plant, is one of the leading factors in highway maintenance essential to efficient and economical work. In urban areas suitably placed central depôts, with railway sidings into which materials can be delivered direct, are a great convenience, and involve the minimum haulage of materials. In these days of frequent labor disturbances, as in the case of the railway, dock, and colliery strikes, the necessity of getting all materials on the spot well in advance of requirements has been greatly emphasized of late, in order that annoying delays may be avoided. Delay in any form means increased cost of the work in hand, frequently entails loss of good weather suitable for the work, and always gives regrettable inconvenience to the general public.

Wherever much work is in progress constant inspection and supervision is a good investment, and to this end the inspecting staff should be provided with appropriate means of quick and convenient locomotion.

Local materials should be employed wherever of suitable quality, but some counties are particularly deficient in good quality stone suitable for first-class roads carrying considerable traffic.

Over-"centralization" of the practical work of road maintenance is not desirable. It is apt to lead to so-called "red-tape" methods, costly delays, and lack of individual attention.

Road maintenance should be carried out through the responsible highway authorities by the direct employment of labor, thus ensuring a local interest in the work, close supervision, and prompt attention, which is almost impracticable under any too distant and highly centralized system of administration.

Stereotyped standardized methods in many matters connected with road-making and maintenance are to be deprecated. Such methods destroy the useful application of personal experience and judgment to individual cases, and so lead to mere routine and lack of interest. It is unlikely that there can ever be any universal solution of the road-problem, inasmuch as local conditions and requirements, character and extent of the traffic, local facilities of obtaining suitable materials, considerations of cost and the like, must ever be deciding factors in arriving at the most suitable and satisfactory mode of treatment in each particular case.

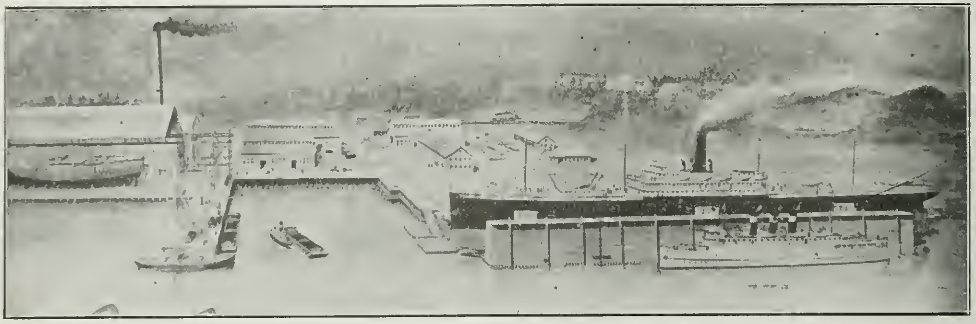
INTERNATIONAL ENGINEERING CONGRESS, SEPTEMBER 20th-25th, 1915.

The International Engineering Congress at San Francisco is to be conducted under the auspices of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Society of Naval Architects and Marine Engineers, assisted by a committee of 18 California engineers. The vast scope of the congress is indicated by the fact that it will be divided into 11 groups of sub-congresses, the reports of which it is calculated will fill 11 large volumes. Chief among these branches will be that dealing exhaustively with the problem worked out in the construction of the Panama Canal, and the influence of the canal on world commerce, commercial trade routes and general transportation problems. Col. Geo. W. Goethals will have charge of the presentation of all canal topics. Aside from general engineering topics, the section devoted to the canal will be treated as follows:—

1. Col. Goethals' general report. 2. Dry excavation of the Panama Canal by Col. Goethals. 3. Dredging the canal. 4. Terminal works, dry docks and wharves of the canal. 5. Meteorology and hydrology of the zone. 8. Designs of locks, dams and regulating works. 9. Methods of construction of same on the Atlantic side. 10. Same on the Pacific side. 11. Designs of lock walls and valves. 12. Spillways. 13. Gates of the canal. 14. Electrical and mechanical installation. 15. Emergency dams above locks. 16. Municipal engineering and domestic water supply in the zone. 17. Reconstruction of the Panama railroad. 18. Aids to navigation of the canal. 19. Geology of the canal zone. 20. The working force of the canal. 21. Sanitation in the zone. 22. Purchase of supplies for the canal. These papers and addresses will constitute practically the official technical record of the work.

PRINCE RUPERT, B.C., SHIP-BUILDING PLANT.

Work was started in June, 1913, on the construction of a ship-building plant at Prince Rupert, B.C. The contracting firm of Beer's, Limited, has under construction, in addition to the ship-building plant, the power-house, machine, boiler and blacksmith shops and foundry building, and hope to have the entire contract completed by August of this year. The accompanying illustration gives a general view of the arrangement of the plant.



General View of the G.T.P. Ship-building Plant at Prince Rupert, B.C.

The power-house is constructed of steel and concrete on a heavy concrete foundation, with a slate roof. It measures 104 x 148 ft. and is about 65 ft. in height. The machine shop is also a steel frame building, 75 x 150 ft., resting on a concrete foundation. The boiler, blacksmith shop and foundry are similar to the machine shop in size and general construction. The shipbuilding plant is constructed with a steel frame, and is equipped with a large travelling crane. Its size is 160 x 300 ft.

The above-mentioned firm, of which Mr. N. B. Beer is manager, is executing the contract for the Grand Trunk Pacific Railway.

TIMBER FLUME CONSTRUCTION.

Timber flume construction and fluming are discussed in a bulletin just issued by the United States Department of Agriculture. The publication considers the subject from the practical standpoint of the logger who has to get his material out by these means.

The V-shaped wooden flume is held to be superior to the box or square-sided form, because it requires less water and, on the average, less repairs than the other type, is better adapted to act as a slide on steep grades, and offers fewer chances for jams. Concerning a third type, the "sectional" metal flume, semicircular in form, the prediction is made that it will eventually come into wide use. Such a flume is strong and light, and can be quickly taken apart and transported from one place to another to be set up again.

When building flumes a good plan is to erect a small sawmill at or near the upper end of the flume location to saw out the material needed for construction. Such material can be floated down the flume as fast as the latter is built and used for its further extension.

For handling railroad cross-ties, cants, poles, cordwood and the like, a flume with the sides of the V, 30 in. in height is large enough. For handling logs, piling, long timber, or brailed sawed lumber, a height of from 40 to 60 in. is recommended. The best angle for the V is put at 90°.

Flume lines should be surveyed with enough care to ensure evenness of grade. Grades should be kept below 15% wherever possible, and the best results are obtained with grades between 2 and 10%. A careful preliminary survey, followed by a location survey, using a transit and level, will make it possible to obtain a reliable profile map which will serve to show the prospective operator what the grading should be at different points along his line.

Abrupt curvatures in a flume should be avoided, for they are likely to cause jams. Curves should rarely be permitted to exceed 20°. The longer the material to be handled in the flume, the less abrupt should the curvatures be. It may be necessary to blast out rocks and boulders, or projecting points of bluffs, or to trestle, or even tunnel, to eliminate abrupt curves or maintain an even grade.

Some flumes are built with only the lining or inside of the box of sawed lumber, the brackets or frames which support the sides of the V being made from round pole wood flattened on one side, and the sills, stringers, braces and trestling of small round timber or poles. Sawed material is recommended for flume construction, however, wherever it can be obtained at reasonable cost.

The "boxes" or sections of a flume vary in length from 6 to 20 ft. Sometimes the boxes are made of only one thickness of boards, but more often of two thicknesses with the joints broken by varying the width of the boards. Sometimes, also, a single thickness of boards is used, with battens spiked over the joints on the outside in the section between the brackets. In still another form the battens are continuous. On curves the boxes should be shorter than on straightaways, and the bents, arms, and braces correspondingly closer spaced. In general, on curves of from 0 to 10°, the boxes should be jointed at least once in every 12 ft.; on curves exceeding 10° and less than 15°, every 8 ft.; and on curves of more than 15°, at least every 6 ft. Very abrupt curves also require increased bracing, in addition to shorter spacing of the arms and brackets. Flumes should also be strongly reinforced at points where extensive shipping is to be done or much material loaded into the flume over the sides.

If the storage facilities at the lower end of a flume are not sufficient for all the material that can be handled during the period in the spring when melting snow and early rains furnish an unusual volume of water, the construction of small holding reservoirs or "catch basins" at different points along the line is recommended. These may be formed by damming up some small stream; or natural ponds, favorably located, may be used for the purpose. In this way such material as it is not necessary to handle clear through at once can be diverted temporarily. A small artificial pond or reservoir at the upper end of a flume in which to "land" or "bank" the material to be shipped is also advisable, especially when handling logs, cross-ties, or heavy manufactured material of any kind.

Editorial

THE CONSERVATION OF WATER-POWER.

The question of conservation has to do with the policy, not only of the governments, federal and provincial, but also of the people at large, with regard to those resources, useful to man, which are supplied by nature in a form easily adaptable to immediate utilization, and particularly with regard to those natural resources, not uniformly distributed, which are limited in extent or in quantity. Among such natural resources are the minerals in the earth, the forests growing upon the earth, and the waters flowing over the earth. Whether applied to any or all of these, a policy of conservation should, manifestly, be directed neither to a locking up or withdrawal from use, on the one hand, nor to an indiscriminate or wasteful utilization, upon the other hand. Economy, in its best sense, should prevail, but an economy which has regard for both the present and the coming generations. These natural resources are placed by nature for the use of man, the man of to-day and the man of the future. Where present and future interests conflict, those of the present are paramount. It is not justifiable unduly to place burdens and restrictions upon the present generation out of regard for those to come after us, nor unduly, by present extravagance, to impose unnecessary burdens upon the future. More than that, neither desires for the present nor for the future should be made the justification or pretext for measures in conflict with the fundamental laws of personal and property rights which are, under our constitutional government, the safeguards of our free institutions.

Conservation, then, should denote the policy of the economical utilization of these natural resources, and of the utmost protection, within the law, of such economy, consistent with the needs of present and of future generations.

The two great, natural sources of energy available are coal deposits and water-powers. The known supply of bituminous coal, while sufficient for a few centuries to come, assuming that the present rate of consumption continues, is in fact limited, as its cost to the consumer gradually increases as the supply diminishes. While the cost of developing water power is considerable, the development of electrical transmission of energy has made water-power development feasible as a business proposition, as against the cost of steam power, to the extent that the amount of water power which is yet undeveloped, but which could be economically developed at the present time, amounts to millions of horse-power. As fuel grows scarcer and as the science of electrical transmission progresses, further water-powers, now merely potential, will be available for the market. It is computed that under average conditions about fifteen tons of coal are required to generate one horse-power a year. The use, therefore, of the water power now unused but economically available, would reduce the annual coal consumption by a remarkable percentage. Thus by the extended utilization of one source of energy, water power, two objects of conservation would be accomplished,—the utilization, without loss, of one natural resource, and the saving from loss of another.

Herein lies the peculiar adaptability of the policy of conservation to the use of water-powers. The three natural resources referred to represent fairly three distinct classes, or kinds, differing in respect of their quality of persistence. The mineral supply, in this case the coal deposits, is limited by its fixed and approximately computable quantity. In the case of timber, while the present supply is limited it, nevertheless, is naturally renewed. Indeed, the non-use of the quantity ripe for use is itself a waste; but, comparatively speaking, timber is a recurring, even if not a constant and undiminishing, natural resource. But water power is constant. The supply is not diminished by use, for in itself it consists in the development and use of two constant factors, viz., supply of water, and a head and fall, through which the weight of the water creates energy developable for practical use.

Every ton of coal used is forever lost as a source of energy. The use of every fifteen tons of coal means that the natural sources of energy have been forever diminished by an amount equivalent to the use of one horse-power for an entire year. To the extent that any quantity of coal is used up for energy before the time when its use is necessary, in place of an equal amount of energy from water power, such use constitutes a waste of energy. On the other hand, the non-use of any quantity of water power, through lack of development and of use of water-powers, the development of which is commercially feasible, means a waste of energy which can never be recouped. So far as such waste of water-power energy is accompanied by the further waste of coal energy, which the water-power energy might otherwise replace, there results a double and continuous loss or waste of the energy available from natural resources and, therefore, of these two natural resources themselves. The primary object of the conservation of natural resources, which is to preserve them from waste, is manifestly doubly opposed by any policy which defeats or postpones the development and utilization of water-power energy.

Because it is inexhaustible and because its use replaces that of another and exhaustible natural source of energy, water power is the most potent of all natural resources, as a subject and agency of conservation. In the case of a limited, exhaustible, and rapidly diminishing supply of a natural resource, such as that of coal deposits, the forces of conservation should be directed to the prevention of use, as far as consistently possible. But the correct view of conservation inevitably leads to the demand that, in the case of water-powers, there shall be encouraged and promoted the greatest and most immediate use possible.

SANITARY SEWER FILTRATION.

Too little is known of the infiltration of subsoil water into sewers and of the escape of sewage en route to the outlet. Undoubtedly there are a good many conflicting conclusions pertaining to the subject, but there are as well numerous instances to indicate that the infiltration of ground water into sewers is costing municipalities large sums in pumping and treating this water at purification and disposal plants. There are systems where newly laid sewerage systems discharge ground water in quantities equal to a considerable percentage of their capacity, before house connections are made.

Reasons that have been advanced for the general delay in acquiring more detailed knowledge and data on ground-water flows centre largely around the historic fact that the combined sewer preceded the separate sewerage system. In the construction of the former, tight joints were not an important item, otherwise, ground and surface water would have had difficulty in finding its way into the system, such a condition rendering it less efficient. Entering upon the design and construction of separate systems, engineers and contractors somewhat included the importance of perfect jointing and the resulting leakage feature has become prominent. An instance is on record at New Orleans of the leakage of ground water into sewers attaining an extent of 1,250,000 gallons per square mile. This infiltration, perhaps not objectionable in storm sewers or drains, is unquestionably so in other sewers and the importance of careful design and workmanship to reduce leakage to the least possible amount is perhaps no greater in any other branch of municipal engineering.

Obviously, the amount of filtration is a function of the head of ground water on the sewer, of the linear measure of joints in the case of pipe sewers, and of the superficial area of the interior of brick or concrete sewers. The volume is usually stated as so much per acre, per square mile, per mile of sewer, per capita or percentage of dry weather flow, but there is little information by which an estimate may be made based on the fundamental considerations mentioned above. There should, at least, be some regulations to apply to work done by contract. This would naturally involve a determination of how much water the sewer might be allowed to carry without materially injuring its usefulness. This determination would depend upon the number and circumference of the joints.

At a meeting of the American Association for the Advancement of Science, Mr. J. N. Ambler incorporated in a paper which he read on this subject a part of his own specifications covering sewer construction. While effecting some very careful work and acting as a powerful deterrent to poor construction, the specification was not regarded by the contractors as unduly severe. Mr. Ambler states in his paper that he once laid a mile of large sewer through exceedingly swampy land passing several streams with the result that not more than a stream ¼-inch deep was flowing from the lower end of the sewer upon completion.

The following is an outstanding part of his specification:—

It is the intent of these specifications that no more leakage of ground water into the sewer be allowed than is admissible with a first-class piece of work, in which care has been exercised to get as near as possible to a watertight result.

To determine the admissible amount of leakage, the length of a joint will be considered as the outside circumference of the spigot end of a pipe.

Leakage not in excess of two gallons per day of twenty-four hours for each foot of circumference of every joint will be considered admissible, the amount of flow to be determined by the engineer's gauging in each section, by means of a notch board.

The contractor agrees that for each 10,000 gallons per day of twenty-four hours by which the total flow of the sewer exceeds what the total flow should be, when figured on the basis already given, a deduction of $100 from the contract price will be made.

This will not apply further than to a total flow resulting from three gallons per day of twenty-four hours, from each foot of joint length, beyond which figure the sewer will be regarded as not in compliance with this contract.

PROTECTION OF UNDERGROUND SURVEY POINTS.

In mining work it has been found that protection against rot of survey points is most important. The work of the mine surveyor largely hinges upon their proper location and upon their not having been disturbed, but in order that the survey stations may possess a longer life of service some method must be adopted to prevent decay or molestation.

If survey plugs are driven flush with the rock they are less subject to rot than when allowed to project. The use of horse-shoe nails has given place in many instances to brass spads. When survey points have to be set in timber, especially in new timber near a face, it has been found well worth while to carry the point down from the spad in the cap to a point on the sill or on a hub in the bottom. The cap and consequently the spad is more subject to movement than the point in the bottom. Furthermore, with the point set in the floor, any movement can be readily detected.

ULTRA-VIOLET RAYS STERILIZATION OF WATER IN AMERICA.*

A FEW weeks ago the contract was awarded by the City of Niagara Falls, N.Y., to the R.U.V. Co., Inc., of New York, for the installation of 35 "Pistol" lamps for the sterilization of water by the ultra-violet rays of the mercury vapor quartz lamp. This is the first municipal installation of the system in America. The capacity of the filter plant in which they are to be used is 16,000,000 gallons per day.

The lamps will operate in banks of seven, and will be spaced 30 inches apart. Each bank will rest in a concrete channel 2 ft. wide, 3 ft. deep and 26 ft. long. Water will pass through the channel at a rate that will allow an exposure of 30 seconds to the ultra-violet rays.

The cost of the installation will be $19,800, which will be augmented by the necessity of rectifying the electric current from alternating to direct. This equipment will cost approximately $2,200. The guaranteed cost per million gallons for maintenance comprises current at 7 cents, and lamp renewals, based on a 2,900-hour life, 60 cents.

The Niagara Falls plant has been using about one grain of coagulant per gallon and five pounds of bleach per million gallons, thus costing about $1.50 per million gallons for chemicals. With the introduction of the new process it is expected that the plant will be made more economical as well as more efficient.

[* An article on water sterilization by ultra-violet rays appeared in *The Canadian Engineer* for June 25th, 1914.—Editor.]

The Dominion Creosoting Company, Limited, of Vancouver, B.C., has received an order for 160,000 creosoted railway sleepers from the Bengal and Northwestern Railway Company of India. The specifications call for best quality, well seasoned Douglas fir to be treated with 12 pounds of creosote per cubic foot under specified temperature and pressure conditions.

PRESENT TENDENCIES IN ENGINEERING EDUCATION

AS DISCLOSED BY THE PAPERS, DISCUSSIONS AND CONVERSATIONS AT THE ANNUAL MEETING OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, AT PRINCETON, N.J., JUNE 23-26, 1914.

By C. R. YOUNG, B.A.Sc., C.E.,
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THAT the engineering profession has not yet attained a status in keeping with its importance is amply evident from the spoken and written words of its thoughtful members. Duties, often of a judicial character, are performed under conditions inimical to the calm and thorough consideration of all the factors of the problem in hand. The independence of the physician or of the lawyer is enjoyed in much less measure by the engineer. His lack of activity in public affairs must be admitted. As yet, he lacks social consciousness.

Every thoughtful engineer has a vision of what his profession ought to be. Primarily, membership in it should involve the capacity to meet new and unexpected situations promptly and effectively. The engineer must be able to devise, unaided, his own plan of campaign, must forge his own weapons and wield them skillfully and courageously. He must be, as President Hibben put it, a scientist, not a technician; he must know not only the facts but the causes of the facts. Like the great physician, he should, to a large extent, be the maker of the conditions under which he works. More frequently than he now does, the engineer should be called upon to fill responsible executive positions requiring both technical and business training. He should be a loyal supporter of every movement for the betterment of his own profession and not only should he have convictions on public questions based on conscientious study, but he should take the part that the state requires of every good citizen.

The disparity between the engineer as he is and the engineer as he ought to be can be lessened only by a powerful transforming agency. Various opinions are held as to what this is to be. That imperfect education of engineers is responsible for many, perhaps most, of the ills which the profession now suffers, cannot be doubted when one hears the testimony of those qualified to judge respecting the fitness of the engineering graduate for the work of the world as he leaves the college halls. Professor John B. Whitehead, in reporting the results of the investigations undertaken prior to establishing a Department of Engineering in the Johns Hopkins University, states that "the average engineering graduate is wanting in general education, in powers of expression, in imagination and ability to reason." He cites in this connection the conclusions of Professor C. H. Benjamin, dean of the engineering schools of Purdue University, who examined the history, subsequent to graduation, of 3,500 graduates in engineering, particularly with respect to their fitness for professional work and with a view of ascertaining how educational training could be altered with promise of improvement. Dean Benjamin found that the graduate has little knowledge of commerce, business methods and economics, and must devote himself in some way to acquiring further information and knowledge of affairs for several years to come; that the literary side of his education has been too much neglected; and that the graduate is frequently unable to express himself properly in either writing or speaking. Among the educators, engineers, employers, and others consulted by the Johns Hopkins University, there was general recognition of the imperfections that have been mentioned. Professor Whitehead states that complaints of two great insistence on professional training to the sacrifice of fundamental and cultural studies were particularly widespread.

From the papers, discussions and conversations at the Princeton meeting of the Society for the Promotion of Engineering Education it appears that improvements in engineering education are to come principally in connection with (1) the subjects taught, (2) methods of teaching, (3) the teacher, and (4) administration.

The Subjects Taught.—In framing new engineering courses, or in the improvement of existing ones, the modern educator will see to it that whatever is taught is closely related to the entrance requirements of the college, to the probable character of employment of its graduates and to the personal qualities desirable in an engineer. His master-motive will be the student, not the subject.

With a course of given length, the scholarship and general equipment of the graduates will be largely determined by the conditions of entrance. With these fixed, the institution is automatically classified as a trade school, a professional school, or a compound of the two, and the subjects taught must follow.

Effective meeting of the needs of the community demands that the technical college shall carefully and continuously study the shifting field of employment of engineers and train its students accordingly. Not only must the broad departments of engineering likely to absorb graduates, as civil, mining, mechanical and electrical engineering, be considered, but the probable *range* of employment of the average graduate should receive attention. So frequently do graduates in one department find their life work in another department that the student should, in prudence, be equipped for transfer. There are now arising, thanks to the joining of technology to business, an increasing number of positions demanding of their incumbents both technical and business training. Professor C. F. Scott is authority for the statement that one-half of the members of the three principal engineering societies of the United States are in executive positions. But few are, or will be, engaged at wholly technical pursuits and of these only a minority will be so occupied for long. In all probability, a large number of graduates of engineering colleges will in the future be called upon to assume duties of a mixed technical and executive character. Instruction in technical institutions must anticipate this.

For business and professional reasons alone, and quite apart from higher motives, engineering education should aim to develop in the student character, intellectual capacity, well-ordered knowledge of his own field, knowledge of men, address and popularity. In purely technical pursuits the last three are less important than the first three, but for the majority of positions that engineers are called upon to fill, knowledge of men, address and popularity are of the utmost consequence. Their indispensability in the field of the engineering salesman is obvious.

In so far as specific subjects of the curriculum tend to develop these personal characteristics in students they are useful and that group of subjects giving the best balance in equipment is the most desirable.

There is now general agreement among engineer educators that three classes of subjects should be taught: technical subjects, economic subjects and cultural subjects.

Technical subjects, based upon the physical, chemical and mathematical sciences, give to the student that introduction to professional practice required in order that he may become an engineer. The selection must be made to correspond to the probable range of employment of the average graduate and at the same time to enable the undergraduate, in democratic institutions at least, to earn a living and something more during the holidays. Limitations of time require that only those subjects in which the student most needs assistance shall be taught. Many reading or descriptive courses might, with profit, be left entirely to the student. In presenting those subjects which are given a place in the curriculum, the usual situations and problems should be given priority over the unusual. In the writer's opinion, much time is wasted in giving elaborate courses in higher structures to civil engineering students when only a small percentage of them will, as engineers, have anything to do with such structures. Let the problems that 70 or 80 per cent. of the graduates of an institution will be called upon to solve determine what is taught, rather than those with which 20 or 30 per cent. may occasionally be confronted. Fundamentals, not details, should prevail. Both cannot be taught in college and it is obvious which should give way. The attempt to give manual dexterity in field work, shop work or in routine testing is an anomaly in an institution for the training of professional men. Such is the work of a trade school.

Economic subjects, devised to reveal to the student economic laws and business methods, are being introduced for the sake of the increasing numbers who will find their life work in a combination of engineering and business. Attention should be given to organization, management, finance, business procedure, commercial law and accounting. There are, however, in the presentation of these subjects, the same difficulties as have been noted in connection with technical subjects, particularly the tendency to encumber the student with multitudinous details. The advocates and teachers of scientific management are especially culpable in this respect. If there is any science in management, surely it can be presented in a few simple principles and it is these that the student should hear about.

Cultural subjects are now generally regarded by those who have given study to the matter as not only a desirable but a necessary part of an engineering course. To attain the higher reaches of success, the engineer must be an educated and cultured man. No corporation, public or private, cares to trust large problems and delicate negotiations to an ignorant, unpolished representative with one idea, and that a technical one. Even if the student cannot see far enough ahead to cultivate "the durable satisfactions of life," he should realize that the shortest cut to failure lies through neglect of the things that put him at once in touch with educated men in other walks of life, upon whose favor his professional success will depend.

It is possible, of course, to so select the cultural subjects incorporated in the curriculum as to improve not only the general education of the student but his professional equipment as well. Expression, whether it be in speech or in writing, in his own tongue or in a foreign one, ministers to both these ends. An acquaintance with literature opens, as Alfred Noyes has put it, "twenty gates to knowledge." Modern, and particularly current, history widens his horizon and makes him a citizen of the world. Sociology introduces him to public problems to the solution of which he should contribute his best thought and effort. In professional as well as in private conduct, a grounding in ethics is vital to him.

Already many institutions have given place to cultural subjects in their curricula. The Massachusetts Institute of Technology strives to carry instruction in English, in one form or other, throughout the four years. Third-year students must spend 45 hours in the first term and 75 hours in the second term on elective work in general subjects. These are arranged in four general options: Economics, English, Modern Languages and History. Fourth-year students may also be admitted to these options without examinations. Beginning with the next session, Columbia University will require for entrance to its engineering courses a three-year college course comprising instruction in English, Modern Languages, History, Philosophy and Political Science. In the new engineering courses recently established at the Johns Hopkins University, 24 per cent. of the total time will be devoted to general educational and cultural studies, comprising English, Modern Languages, Political Economy, Logic, Ethics and Psychology.

It is thus evident that a multiplication of the points of contact with life is the ideal of many engineering educators. Mr. W. H. Rayner, of the University of Illinois, has given effective expression to this view. Says Mr. Rayner: "I believe that it is more important for a senior to gain a good comprehension of present-day labor problems than to spend six or eight hours per week in detailing a plate-girder bridge; and, as an academic means to equip an engineering graduate for intelligent citizenship, it would be more profitable for him to consider the fact that between 10,000,000 and 20,000,000 people in our prosperous America are near the poverty line, and design measures of relief for them, than to design a gas engine."

Methods of Teaching.—Instruction may be imparted by formal or by informal means. The first is undertaken in lectures, recitations and laboratory investigations. The second arises through personal example, inspiration and advice in personal matters not covered by the curriculum. Increasing recognition is now given to the necessity for informal intercourse with students. Only in this way can the teacher really come to know the student and thereby reach and inspire him.

In formal instruction, the best teachers now apparently strive to (*a*) create and maintain interest in what is taught, (*b*) indelibly fix the fundamentals in the student's mind and (*c*) provide the student with means of self-help.

(*a*) Without interest, the student will carry little away from the class-room or the laboratory. How to develop it is the first problem of the teacher, and evidences are not lacking of earnest efforts to find the solution. For engineering students, there should be at the outset a consuming desire to become engineers and a willingness to make large personal sacrifices in order to do so. To create this desire, the teacher must present engineering in an attractive, if not a romantic, light.

Maintenance of interest is only possible by encouragement and frequent assurance of progress on the part of the instructor. The basing of new principles upon what is already known to the student is to him one evidence of increasing knowledge. The tacit inventory-making involved in tracing the inter-relation of subjects is another.

Apart from this mental stock-taking there is a value in constant relation of the new to the old. It is a fact, as Professor William James has pointed out, that the absolutely new makes no appeal.

In the teaching of theoretical subjects it is now regarded as highly desirable to introduce physical notions whenever and wherever possible. Professors Franklin, MacNutt and Charles, in their paper on "Practical Mathematics," repeatedly express this as their belief. Thus:

"In the teaching of mathematics every effort should be made to appeal to sense material and to the quantitative notions which permeate everyday life; and mathematical principles and relations should be visualized wherever it is possible."

" . . . . the only way to marshall the mind-stuff of a young man for the manufacture of ideas is to introduce the drag net of physical suggestion into every discussion. There is no other way to bring intuitive and sense material into the field of consciousness where it may be organized into a structure of ideas."

Of especial importance in maintaining the interest of engineering students is the correlation of theoretical subjects with practical engineering problems. Professor A. B. McDaniel, of the University of Illinois, has effectively pointed this out in his paper on Coördination in Engineering Instruction." Speaking of the teaching of trigonometry, he says:

"Generally, the speaker has found the student equipped with a vague idea of the trigonometric functions. Beyond the fact that they are certain abstract fractional forms, they mean very little to him. He does not readily see their significance in the solution of problems on paper, and in the field. Especially is he deficient in the ability to visualize these fundamental trigonometric concepts and quickly grasp their applicability. The reason for this is clear. *The subject is taught in an abstract way and not in correlation with the dependent branches of engineering.* Some schools, notably the college of engineering of the University of Minnesota, have endeavored to solve the problem by employing teachers with engineering training for the courses in mathematics. This method has proved to be quite satisfactory and efficient. Unquestionably such teachers vivify the subject, and present it in a concrete manner, having always in mind the future applications of the principles which they are drilling into the minds of the students."

(*b*) The indelible fixing of fundamentals in the student mind requires that the teaching shall largely be confined to fundamentals. Sufficient detail to enable the student to relate the problem to his own experience or to identify it later in practical affairs is salutary. More than this beclouds the central principle. The reduction of the principles taught to the fewest possible adds to clearness. Encyclopedic teaching is no longer in favor. When President Wilson began his teaching career he strove to compress into his lectures the greatest possible amount of information, but he soon discovered that the true ideal of teaching was not the communication of facts but the development of understanding in his students.

Symbolism in mathematics is responsible for the lack of clear understanding of many principles that for convenience are given statement in mathematical formulæ. Thus, Professors Franklin, MacNutt and Charles find that in their experience when a student is asked to state Joule's Law he will say "*aitch equals arr aye square tee*"! and that it is difficult to get him to say that "the amount of heat generated in a particular piece of wire during a given time is proportional to the square of the current in the wire and to the time that the current continues to flow." The aid to be derived in fixing principles in the mind of the student by their expression in words rather than in symbols is indicated by Professor Dugald C. Jackson, of the Massachusetts Institute of Technology, in the following:

"I am strongly in favor of emphasizing the instruction in mathematics, but particularly in calculus, on the side of the interpretation of the meaning of equations into simple terms of English, as the terms of English are those in which one ordinarily thinks, and it is necessary to make such interpretation in order that the logical processes of mathematics may be incorporated with our ordinary processes of thought and analysis."

On the principle that no operation is clearly understood until one performs it one's self, the subject should be drawn out of the student rather than put into him. He should solve his own problems, make his own discoveries and answer his own questions, merely receiving the guidance and suggestion needed to keep him on the trail. It is this method that Dr. E. J. Berg follows at Union College, Schenectady. While ideal, it has the disadvantage of requiring the expenditure of much time on the part of the instructor as well as a large teaching staff.

(*c*) Recognizing that the student must rely wholly upon himself when his college days are over, the judicious teacher will seek to provide him with adequate means of self-help. Primarily, the student must know how to study, but, as Professor George L. Sullivan has shown in his paper "Teaching Engineers How to Study," he usually does not. Increased attention must be given to this matter and an effective method of securing it would be to encourage students, by special recognition, to devise improved methods of study of the various subjects of the curriculum. An experiment of this kind is now being tried at Brown University.

So large a part does judgment play in the work of the engineer that a special effort should be made to develop it in college. Opportunities for choice and decision must be created and wherever possible responsibilities must be placed on the student. Let him fix important features of the problem in hand, although he may have to do it over several times as a result of erroneous assumptions. Require him to seek out his own data from the books, tables and typical plans available. Through the blunders, rather than by the fortunate steps he makes, he will understand the value of judgment and the meaning of responsibility.

Success in dealing with practical situations requires that the engineer shall be able to formulate the scientific problem from a layman's statement of conditions. One of the greatest difficulties of the young graduate is in making a book problem out of the information supplied him or to apply the theoretical principles learned in college to the securing of useful results from a mass of data gathered, perhaps, by himself. To remedy this, practice in formulating theoretical problems from practical statements of conditions and requirements should be given in engineering courses.

The Teacher.—Without able and inspiring teachers no institution can influence the student deeply or for long. Above all other qualifications demanded of one who would guide youth is character. No connivance at sharp practice, "tricks of the trade" or the operations of the disaster-inviting "bluffer" can be permitted. Varied ability, too, is essential. The teacher must possess mental calibre, an unusual facility of expression and tact in dealing with man, especially unruly and, at times, erratic students. Extreme cleverness in an instructor is, however, a handicap. The student's difficulties are not his

difficulties and the discussion will in all probability be carried over the heads of and beyond those who are supposed to profit by it.

Scholarship should be a prerequisite for teaching. Only one who is an up-to-date, first-hand authority on the subject he teaches can win and maintain the confidence of students. This necessitates a certain amount of research and writing. Through such activities the teacher not only extends his knowledge, but maintains a perennial freshness and interest in what is perhaps no more than a narrow specialty. Danger to the effectiveness of the institution as a teaching organization, however, lurks in the effort to carry on a great deal of research or writing. An eminent professor, upon outlining the various researches that he proposed to carry on during the approaching session of college, was asked what he would do with his students. "Neglect them," he replied. Little objection could be raised to investigations respecting the effectiveness of various methods of teaching and much of this legitimate form of research is now being undertaken by engineering instructors. An evil also exists in the practice, happily not widespread, of institutions urging young and immature instructors to write text-books with one eye on the advertising value to be derived therefrom.

No one should attempt to teach engineering subjects without enough experience in engineering to convince his students that he possesses more than book-knowledge of that which he teaches. As an adviser, he must have a knowledge of various fields. sufficient at least to give perspective. Much has been said concerning the engagement of practicing engineers as instructors on "part time." Engineering experience, as against a communicable knowledge of theoretical principles, as a qualification for effective teaching in a technical college, is losing its hold as a fetish. Directing a squad of draftsmen or keeping a contingent of contractors out of each other's way is not precisely the training that is most useful in enabling a man to impart a knowledge of the great fundamentals of engineering science. Teaching is a vocation requiring special fitness and special training quite as much as any other calling. An engineer of vast experience may be quite useless as an instructor. There is too great a disposition on the part of those who are called in from the field to teach to present the subject in a bewildering maze of detail. Their traffic with fundamental principles occurred so long ago that they have half forgotten that such exist. What they give to their students, therefore, are details, short-cuts, approximations and serviceable turns in the practical execution of work in office and field. The maintenance of a private practice of any considerable extent is, so far as its aid to teaching is concerned, of doubtful value. Not even the engineering professor can serve two masters. The advertising value to the institution does not compensate for the loss of personal contact with students inevitable with such an arrangement. So long as the major interest of the teacher is his students, the college will profit by allowing, or perhaps encouraging, private practice, but when academic duties are performed in time not otherwise occupied, the college is the loser.

Personal qualities of a high order are rightfully demanded of a teacher. His sympathies must be wide and his appeal to the student must be many-sided. In enthusiasm, however, is found his greatest source of power. Without it, he will be a failure, no matter what his other qualifications may be. Dean Orton, of the Ohio State University, has expressively put it in his remark that "About all a teacher is good for anyway is to 'enthuse' boys."

Good teachers can neither be obtained nor retained without inducements other than the opportunity for service —compelling though that may be to an idealist. The desire for a salary adequate to the position should be pardoned. Reduction of clerical and routine work to a minimum is highly desirable for one whose chief asset is his freshness and enthusiasm. Appointments, promotions and rewards must be based on capacity for the particular service required. If teaching is the service desired, let rewards be governed by ability to teach and not by demonstrated ability as an engineer, an original investigator or a writer.

Co-operation among teachers will profoundly minister to the effectiveness of instruction. Without it, the results achieved by one may be offset by another. There must be "give and take" in the matter of inter-relation of courses. Mutual help in faculty seminars and conferences is desirable.

Administration.—Since we teach not as individuals but as institutions, constant direction of both staff and students by a central authority is a necessity. For the good of the college and the effectiveness of its teaching no teacher should be permitted to carry an overload. His personal power with students depends, to a remarkable degree, on his enthusiasm, freshness and elasticity, and these cannot be maintained under a burden of overwork. Leisure is the one thing that the teacher should not be permitted to forego. There is, too, such a thing as a student load. The administrative head should assure himself that it, as well as the staff load, is not excessive. Much attention is now being given to such matters as the length, inter-relation and balancing of courses, the length and frequency of lecture, recitation and laboratory periods, the size of classes, the part of the day utilized, and allied problems vitally affecting the student. A halt has been called in the institution of graduate courses in engineering as a result of the indifferent success of the Harvard graduate school, and the action of the Johns Hopkins University in the establishing of a four-year undergraduate course with the provision for graduate work later is indicative of the tendency in this matter. A pronounced reaction against specialization is now in evidence. But little election is allowed in the new course at Johns Hopkins, and many educators are inclined to favor the attitude of such institutions as the University of Pennsylvania, which, for example, requires all students in civil engineering to take the same course.

Indications of Change.—Indications of profound change in the methods of engineering education are not wanting. Dean Gardner C. Anthony, in his presidential address to the Society for the Promotion of Engineering Education at Princeton, declared that the pendulum had reached the extreme position in its swing toward vocational training. The committee on Entrance Requirements of this society put themselves on record as deprecating the acceptance by engineering colleges of more than two Carnegie units of time devoted to manual training. The Johns Hopkins University designedly omitted shop work, foundry work and manual training from the curriculum. The University of Washington has completely revised its courses in the direction of greater attention to cultural studies. The three-year preparatory course for entrance to Columbia has already been mentioned. There appears to be, on every hand, ample evidence of a coming liberalization of engineering education. The ideal of ex-President Charles W. Eliot is more generally accepted than ever before: "Education for efficiency must not be materialistic, prosaic or utilitarian: it must be idealistic, humane and passionate, or it will not win its goal."

A FORM OF SIPHON SPILLWAY.

THE following illustrations are descriptive of a device for regulating the water level in a canal, stream or reservoir, and to provide for the disposal of surplus water in time of flood. It was developed by Mr. G. F. Stickney in connection with his work as designing engineer for the New York State barge canal, on which waterway it has been adopted. It is claimed by the inventor that the device will reduce considerably the size of a structure necessary to dispose of a flow of water, as a dam or spillway, and thus effect a material saving in its cost. Its automatic features contribute greatly to economic operation. In the development of water power in the storage of water for irrigation or other purposes, or in the increase of navigable depth of streams, there are problems such that those interested in the same will find the following descriptive notes of interest:—

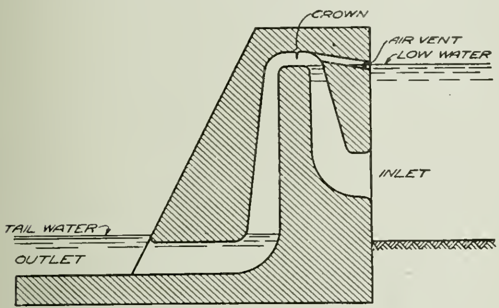


Fig. 1.—Section Through Siphon Spillway.

Fig. 1 is a sectional view of the siphon spillway. It is a closed conduit of an inverted "U" shape extending through a dam where a fall is available, thus utilizing the siphonic principle to induce a high velocity of flow. The siphon is built in the masonry of a dam, and its action is entirely automatic. The flow, when established, is comparable to that through a submerged sluice-gate with a velocity of from 60 per cent. to 80 per cent. of the theoretical velocity due to the head.

Fig. 2.—Upper and Lower Sides of Spillway. The Former Shows Inlets and Air Vents; the Latter, Siphons in Operation.

The crown of the siphon is entirely above low water level. The upstream leg is sufficiently long to bring the inlet well below the water surface so as to avoid the entrance of ice drift, etc. The downstream leg is made as long as is practicable in order to take advantage of all the head available. It is not necessary that the outlet be submerged.

The action of the siphon is controlled by an air-vent which pierces the up-stream wall at the low-water level. When the water above the dam rises the vent is submerged so that no air can pass into the siphon. The water then spills through the crown and the down-stream leg. At a certain depth of overflow the air in the siphon begins to pass out with the flowing water; and, as the air becomes rarified the water rises to a higher level in the crown than the surface of the stream outside. Within a short period of time the crown becomes completely filled with water. The siphon is thus primed and rapid flow established. It will continue until the water surface has lowered to such an extent as to expose the vent sufficiently to admit a volume of air into the crown. Then the siphonic action ceases. A fluctuation of the water surface of from 3 inches to 1 foot, depending on the size of the siphon, is necessary to start and to stop the flow. The limiting height of head which may be utilized to produce flow is 33.9 ft.—the height of the longest column of water which atmospheric pressure will sustain.

Siphons of large capacity may be built with the top of the crown well above the highest water level, but in such cases a simple automatic priming device is necessary and both ends of the siphon must be submerged.

Concerning this device it is notable that there are no adjustable or working parts liable to derangement or deterioration. It is genuinely automatic in action; and it will maintain a water surface which will fluctuate between narrow limits regardless of the flow, thus giving a reasonably constant level. The great volume of water which it will discharge per unit of length is also a notable feature.

Fig. 2 illustrates an installation built for the Tennessee Power Co. on the Ocoee river. The spillway contains 8 siphons, each 8 ft. square in section, 4 of which operate under a head of 19.2 ft. and 4 under a head of 27.2 ft. They have a total capacity of 1,650 cu. ft. per second. A rise of 4 inches starts the siphons.

The inventor claims for the device the following special uses:—

1. To regulate the water surface in a stream above a dam at the highest permissible level, giving the maximum head for power development, the maximum storage, the greatest navigable depth, and reduce the fluctuation of the water surface to a minimum.

2. To provide an outlet from a flume or forebay, where a constant flow is maintained, which will operate with a slight raise in the water surface and will discharge the entire flow, in case of a sudden shutdown of the power plant or a sudden obstruction of the flow.

3. To use in place of gate-valves to discharge water from a reservoir. The crown of the siphon may be placed entirely above the water level, so that no leakage is possible, and the siphon may be arranged to be operated by the manipulation of small hand-valves.

On June 15, articles of incorporation were filed with the Secretary of State for the South-West Pacific Railway Company, which purpose building a railway from Denver, Colo., to San Diego, Cal. The capitalization of the company is given as $2,200,000; and the approximate cost of the construction of the total 2,200 miles of road is placed at $105,000,000. The main line from Denver to San Diego will be 1,021 miles in length, while branches will be constructed from Denver to Salt Lake, and from other points to several mining districts.

A LAND SURVEY PROBLEM.

By J. A. Macdonald, Ottawa, Ont.

VERY little information is to be found in technical journals on land surveying, and there is no journal in America devoted exclusively to this important subject. As land surveying goes on continuously, and as each county supports, ordinarily, at least two land surveyors, it is plain that, in the United States and Canada, there must necessarily be a large number of men interested in this work. In late years, as land survey work grows less, most land surveyors are also civil engineers, or understand that part of civil engineering so far as instrumental surveying goes, though they may not be designers of bridges, tunnels, aqueducts, etc. There are, however, a large number of civil engineers who know little of practical land surveying. The following notes, which relate to a survey of a stone quarry and mill property contain a number of points illustrating several methods which are more or less essential to a practical knowledge of the subject, and should commend themselves as well to every surveyor of experience as they are a model in their way. Fig. 1 is a sketch of the survey to which they pertain, and Table I. gives the field notes themselves. The former, of course, should appear on the right-hand page of the field book, and the latter on the left-hand page.

Fig. 1.

It will be seen in this instance (Table I.) that the tree was sighted from each corner of the survey and its bearing recorded. These lines, when correctly plotted, intersect at one point. If the plot had not closed, then these bearings would have been plotted, as shown in the dotted lines on the sketch, and they would not have intersected at one point, the first line which deviated from the common point indicating that the preceding course had been erroneously measured, either in bearing or distance, or else wrongly plotted. Such bearings taken to a common point, enable us to locate an error either in the field notes or in the plot. The mill is located by bearings taken from corners B and C. The quarry and entrance thereto is located by bearings taken from known points in the lines 3 and 4.

Latitudes and Departures and Their Computation.—There is only one correct way of computing a compass survey, and this is by latitudes and departures. The latitude of a course is the length of a course into the cosine of its bearing. If the forward bearing of a course is northward its latitude is called its Northing, and is reckoned positively, or plus; while if the course bears southward its latitude is called its Southing, and is reckoned negatively, or minus. The Departure of a course is the length of its east and west line, or the length of course into the sine of its bearing. If the forward line is eastward its departure is called Easting, and is reckoned positively; while if its forward bearing is westward its departure is called Westing, and is reckoned negatively.

The Meridian Distance of a point is its perpendicular distance from the reference meridian, in the sketch from the north and south meridian point, and the most westerly point of the survey.

Table I.—Field Notes of a Compass Survey.

No. of Course	Point	Bearing	Distance along Course	REMARKS
	Bearing tree	N. 60 00 E.	Ch.	True bearings
	Fence	Northerly	7.20	given, varia-
1	Yard	"	9.75	tion of needle
	Yard	"	11.54	24° 30′ west.
	Garden	"	13.90	
	Corner B	S. 69 15 E.	70.60	
	Bearing tree	N. 10 40 W.		Course 1 is
	Mill	N. 3 45 E.		along centre of
2	S. bank		36.30	the highway.
	N. bank		37.30	
	Corner C.	N. 37 15 E.	59.30	
	Bearing tree	S. 88 45 W.		
	Mill	N. 80 00 W.		
3	Mill road	S. 86 45 W.	9.90	
	Stone quarrie	S. 79 30 W.	30.00	
	Corner D	N. 39 30 W.	60.00	
	Bearing tree	S. 7 30 W.		
	E. bank		10.00	
4	W. bank		11.00	
	Quarrie road	S. 19 15 E.	30.00	
	Corner E	S. 57 55 W.	46.50	
	Bearing tree	S. 56 30 E.		
	Offset, 4.00		0.00	
	" 6.00		5.00	
5	" 8.00		10.00	
	" 7.00		15.00	
	" 3.00		20.00	
	" 2.00		25.00	
	" 0.00		30.00	
	Corner A	S. 30 00 W.	49.80	

The Double Meridian Distance of a course is equal to the sum of the meridian distances to the extremities of the course. The double meridian distances of the two courses adjacent to the reference meridian are equal to their respective departures. The double meridian distance of any other course is equal to the double meridian distance of the preceding course plus the departure of that course plus the departure of the course itself, eastern departures being counted positively, and western departures negatively.

In the computation of area, twice the area of the figure is equal to the algebraic sum of the products of the double meridian distances of the several courses into the corresponding latitudes, north latitudes being reckoned positively, and south latitudes negatively.

Since the departure of a course is its length into the sine, and its latitude, its length into the cosine, of its bearing, these may be computed at once from a table of natural sines and cosines. As it is now customary to read even the needle compass as close as 5 min., the ordinary reverse table is of little use in modern surveying. For land surveying, a 4-place table is sufficiently accurate.

Balancing the Survey.—If the bearings and lengths of all courses have been accurately determined, the survey will "close," i.e., when the courses were plotted to any scale the end of the last course would coincide on the plot with the beginning of the first one, and the sum of the Northings would exactly equal the sum of the Southings (minus latitudes), and the sum of the Eastings (plus) would exactly equal the sum of Westings (minus). All surveyors and draughtsmen know that such exactness is not attainable in practice, and that no plot will close exactly; that neither the north and south latitudes nor the east and west departures will exactly balance. The distribution of these errors of latitude and departure is called "balancing the survey." In Table II. it is seen that the error of latitude is 60 links and the error of departure is 50 links. The distribution of these errors is made as follows:

The ratio of the length of the line joining the initial and final points to the whole perimeter is 17, as found from the field notes. The length of this line is the hypotenuse of a right-angled triangle, of which the errors in latitude and departure are the two sides. Its length is equal to the square root of the sum of the squares of these two errors. This, divided by the whole perimeter, gives the error of closure, which ratio is expressed by a vulgar fraction whose numerator is one, being 1/366 in the example given. For ordinary rolling country the error of closure should not be more than 1 in 500.

A check on the computation of the double meridian distances is found in the fact that when computed continuously in either direction and from any corner, the numerical value of the double meridian distance of the last course must equal its departure.

To Plot a Compass Survey.—Select a point for the initial Station, and pass a meridian through it in pencil. By means of a protractor, mark the bearing and draw an indefinite line from the Station point. On this lay off to scale the length of the course, 5, 10 or 20 chains to an inch, thus establishing the next corner. Through this, by means of a parallel ruler, draw another pencil line meridian, and proceed as before. The bearings of the successive courses may be so combined as to give the deflection-angle, similar to a railway survey, at any station, and these may be laid off from the preceding course as already drawn. Errors are more likely to accumulate in the plot by this method, so that the first is preferable.

Probably the best method of all, but one seldom used, is that by which rectangular co-ordinates of the several corners are computed, and these plotted from a pair of rectangular axes.

Table II.—Form for Computing Areas from Bearings and Distances of the Sides.

Stations.	Courses. Bearings.	Courses. Dist.	Diff. N.	Lat. S.	Departure. E.	Departure. W.	Balanced. Lat.	Balanced. Dep.	D.M.D.	Area.	Area.
			+	—	+	—					
A.	S. 69 15 E.	70.60	.....	25.00	66.00	.....	—25.20	+66.10	66.10	....	1666
B.	N. 37 15 E.	59.30	47.20	.....	35.90	.....	+47.10	+36.00	168.20	7922	....
C.	N. 39 30 W.	60.00	46.30	.....	.....	38.20	+46.20	—38.10	166.60	7674	....
D.	S. 57 45 W.	46.50	.....	24.80	.....	39.30	—24.90	—39.20	88.80	....	2211
E.	S. 30 00 W.	49.80	.....	43.10	.....	24.90	—43.20	—24.80	24.80	....	1071
		286.20	93.50	92.90	101.90	102.40				15596	4948
			92.90			101.90				49.48	
	Error, in lat. =		.60		in dep. =	.50				2/10648	

Area = 5324 sq. chs. or 532.4 acres.

Error of closure = 1 in 366 =

$$(\text{square root of}) \frac{\sqrt{50 + 60}}{286200} = 0.0027 = 1 \text{ in } 366.$$

A Diesel electric railway motor car accommodating 50 passengers and weighing over 70,000 lbs. has run, since the beginning of the year, over 2,000 miles on the railways of Sweden, usually at a rate of 20 to 35 miles per hour. The Diesel engine burns about 9 lbs. of crude oil per mile. The car is propelled by electric motors furnished with current from a generator driven by the engine.

Many thousands of bricks per day are being manufactured by the different brick companies of Fort William. The demand at present is fair and as the season advances will increase. The Alsip Brick and Tile Company is working to capacity and producing 70,000 bricks per day. The Fort William Brick and Tile Company is turning out some 26,000 brick per day. The Superior Brick Company is manufacturing 35,000 brick daily; while, at the new plant of the Mount McKay Products, Limited, great activity is being shown in the construction of new kilns, although brick making for commercial purposes will not be under way for at least two months.

The Canadian Pacific Railway will shortly have 1,095 miles of double track between Port Arthur and Calgary, leaving only about 165 miles still to be double tracked between these points.

During 1913, 10,000 box cars, 1,227 passenger, sleeping, dining, and other cars, and 156 locomotives of different types were added to the rolling stock of the Grand Trunk system. They included 41 superheated Pacific type of engines, 100 other large locomotives, 15 switching engines, 10 dining cars, 15 sleeping cars, 11 parlor cars, 67 first-class coaches, 500 flat cars, 500 stock cars, and a large number of combination cars. In box cars a preference was shown for 80,000 pounds' capacity. The prices paid for the passenger cars ranged from $10,000 for a first-class car to $25,000 for a sleeper equipped for service. Orders placed by this road for 1914 include 10 mail cars, 500 stock cars, 20 baggage cars, 82 first-class coaches, 5 second-class coaches, 4 dining cars, 5 parlor cars, 5 express cars, 200 fifty-ton flat cars, and 300 forty-ton flat cars.

LOCK ENTRANCE CAISSON, PANAMA CANAL.

A VERY interesting feature of Panama Canal construction is the lock entrance caisson which is to act as a floating gate or dam for closing the entrance of the lock so that any of the chambers may be unwatered for inspection, cleaning, or repairs. The following description of it is from the "Canal Record":—

The width of the lock chamber is 110 ft.; beyond the line of the emergency dams, the approach is widened by an offset of 24 in. on either side. The shoulders so formed, with a connecting horizontal sill across the bottom of the chamber, afford a frame into which the caisson is fitted to dam off the interior of the lock. This is accomplished by floating the caisson against the shoulders and letting water into its hold to sink it on the sill.

Pumps in the interior of the caisson are then employed to unwater the chamber, while the water pressure from the outer side will force the caisson securely against the frame, reducing leakage around the edges. When it is desired to remove the caisson, the lock chamber will be filled with water, relieving the pressure, and the water within the caisson will be pumped out to allow it to be floated away. The general principles of construction are the same as in the caissons for Gatun and Miraflores Spillways, but the requirements and conditions of its use make the design of the lock caisson more complex than that of the spillway caisson.

The caisson is designed for interchangeable use at all locks, and will have a draft when light of 32 ft., to allow its convenient handling through the locks. The lower elevation of the sill at the Pacific end of Miraflores Locks, 50 ft. below mean sealevel, in connection with the tidal fluctuation which raises the surface as high as 11 ft. above mean, requires that the extreme draft of the caisson, when sunk, be 61 ft. Provision for a proper freeboard makes the aggregate depth of the structure 65 ft. The achievement of statical stability at the various depths of immersion, without undue bulkiness or excessive weight in the different parts, makes the design of especial interest.

In form, the bottom of the hull will be convex, the ends pointed, and the sides will slope inward from a maximum width of 36 ft. at about one-third the way up from the keel, to a breadth half as great at the top. A typical transverse cross-section of the structure resembles in outline the vertical section through a pear-shaped carbon-filament electric lamp. The horizontal lengthwise sections vary with the inward slope of the sides; in general, they resemble those of the ordinary vessel of commerce, and may be described as flattened ellipses, blunt at the ends to contain the girders and breasthooks by which the pressure will be transmitted to the vertical sills, or shoulders, on the lock walls. The length between the vertical ends will be 112 ft. 6 in., and the extreme length, including the timber cushions, 113 ft. 10 in.

It is desired that the side walls of the locks shall carry practically all the static load from the caisson when it is supporting the water pressure. Accordingly, there will be a number of horizontal decks and end breasthooks to carry the load to the vertical ends; and a system of vertical framing, built intercostally and extending from the keel to the top deck, will transmit the panel loading to the horizontal decks and breasthooks. The essential features of the structure will be the transverse and longitudinal framing, with bulkheads; the horizontal plate decks, girders, and stringers; the girders at the ends and along the keel; the end breasthooks; and the plating to cover the skeleton in forming the hull proper. These elements will all be made from open-hearth structural steel.

The transverse framing system will consist of nine cross frames, spaced about 12 ft. apart and extending the whole height of the caisson, and intermediate frames, spaced at intervals of about two feet between the main cross frames. All will be built intercostally between the five horizontal decks. Two of the cross frames will be built watertight and designated as "Collision bulkheads," to form trimming tanks at each end of the vessel, for maintaining longitudinal stability and settling the caisson on even keel when it is to be put in use. The seven other cross frames will have apertures in their lower sections to make them serve as swash bulkheads for controlling the water within the caisson by which the depth of immersion will be regulated.

A longitudinal bulkhead will extend the entire distance between collision bulkheads, from keel to operating deck, along the centre line. Its lower part will be sufficiently watertight to form two distinct lengthwise compartments, dividing the free surface of the water ballast and increasing the static stability of the caisson, as against lateral motion.

There will be 5 horizontal decks, built continuously from vertical end to vertical end. The two lower decks, 16 and 25 ft., respectively, above the base line, will be entirely plated over with the exception of openings for hatches and manholes, the hatches being made large enough for the installation or removal of the pumps through them. The operating deck, 37 ft. above the keel, will be entirely plated from end to end, and made absolutely watertight. This deck will support the motors for the pumps, with switchboards, gauge registers, etc. The plate-stringer deck, 49 ft. above the base line, will be an open truss with diagonal bracing for the central two-thirds of its length. The top deck, 65 ft. above the base, will be plated over from end to end, with openings for manholes, skylights, deck cranes, companionways, and scuppers.

Six plate breasthooks will be built at each stem of the vessel, at intervals between the decks. They will serve to transmit the end shears from the decks to the vertical girders. One of these breasthooks, situated 31 ft. above the base line, will have its plating calked to watertightness and serve as the bottom for the end trimming tank. At the same level as the breasthooks will be longitudinal intercostals, securely riveted to the transverse frames and to the sheathing.

The skeleton will be entirely sheathed over with steel plating worked in in-and-out strakes, running longitudinally over the frames, making lap seams and butt joints which are to have double splice plates. At all the horizontal decks, and around the pipe discharge and suction openings, the sheathing will be doubled. Fenders against external impact will be provided between the 25 and 49-ft. levels, by bent plates securely riveted to the sheathing, the space between being filled with poured rosin. Towing rings will be attached along the 37 and 43-ft. levels.

End reaction castings will provide connection of the decks and breasthooks, up to and including the 49-ft. stringer deck, with the vertical girders, for transmitting to the latter the reactions of horizontal forces. They will be made of carbon steel and closely fitted during construction.

Along the exteriors of the ends and keel will be fastened cushions of British Guiana greenheart timber. They will be planed to make even contact with the plated sill and reduce leakage to a minimum. Greenheart timber

is notably durable under water, either fresh or salt, and has been used for the sills of the miter gates in the Canal locks.

Pumping System.—The pumps installed within the caisson are designed to regulate the water ballast, determining the depth of immersion, and to unwater any portion of the locks between the upper and lower entrances. Of all the lock chambers, the only ones which can be cleared of water without pumping are the two in the upper flight of Gatun Locks, because they are the only ones the floors of which are below the level of the water at the lower end of the flight. The floor of the intermediate level at Gatun is 13⅔ ft. below sealevel. The floor at Pedro Miguel Lock is at elevation plus 9, which is 46 ft. below the normal level of Miraflores Lake. The upper of the two levels at Miraflores is 18½ ft. below mean sealevel, which means a minimum depth of water in it of about 8 ft. at low tide of the Pacific. Moreover, the caisson dams will afford the only means of working in the dry on the outward faces of the guard gates, and the sills for the emergency dams.

The main pumping system will consist of 4 vertical-shaft centrifugal pumps, having a 20-in. discharge and a 22-in. suction. The practical test governing its design is that it shall be able to pump out in not over 25 hours all the water in the upper and lower chambers of one flight of Miraflores Locks, between mean sealevel and the top of the sill of the lower chamber (El.—50 ft.), the tidal level to be at El. 0 when the pumping is begun, and the tide rising. The total quantity to be pumped out, including 518,000 ft. for leakage, will be about 10,285,000 cu. ft. The average discharge under these conditions, for the entire period of pumping, would be about 13,000 gal. per min. for each of the 4 pumping units. Two of the pumps are to be arranged for pumping out the caisson when it is to be removed from its position against the sill.

Inasmuch as the sill for the caisson is higher than the level of the floor, suction extension pipes are to be provided to cross the sill on the bottom of the chamber, to allow its complete unwatering. The suction extensions will be lowered by cranes on the deck, and attached from a pontoon, similarly handled.

An auxiliary pump, with suitable pipe connections, will be used to regulate the end trimming tanks, flush the scuppers, and scour the sills.

Electrical Equipment.—The caisson will have no means of auto-propulsion, but will be towed from place to place. Its motors will be for operating the pumps, and their details will be determined by the pump characteristics. Four 2,200-volt motors will drive the main pumps, and one of 220 volts potential will operate the auxiliary pump. Another 220-volt motor will drive a ventilating fan. Current will be received at 2,200 volts from chambers in the lock walls, through four flexible cables, and a three-phase transformer is to be provided for the 220-volt motors, and for the lighting equipment. A switchboard will be installed in the operating room, which is on the operating deck, 37 ft. above the base line.

Miscellaneous Parts.—There will be four portable cranes on the top deck, to handle various loads. Each must be capable of raising another at a radius of 14 ft., by 2-man power. The pontoon for making the suction extension attachments will be stowed on the top deck and handled by cranes. A deck capstan, hand-operated, will be provided at each end of the top deck. It must be able to withstand a pull of 10,000 pounds.

Two ventilators, 16 in. in diameter, with hoods of U.S. Navy standard type, will be placed on the top deck, for ventilating the operating room. One, discharging a short way below the 49-ft. deck, will have a multivane exhauster, motor-driven. Twelve 2-in. air vents, to allow the escape of air and gases from the interior compartments, will lead to the top deck. Two skylights, 8 by 16 ft., will be set in the top deck, symmetrical with the axes of the caisson. The covers will be made in two parts, for portability, and a hand-operated device will be provided for raising and lowering them. The skylights will be watertight against a hose discharge under 50 pounds pressure.

Fixed ballast, composed of pig iron punchings and concrete, is to be placed in the bottom of the hull to a normal thickness of about a foot and a half. The pig iron will at all points be at least six inches from the sheathing. Two 70-ft. lengths of anchor chain will be provided for mooring the caisson when it is not in service, and chain lockers for them will be built of reinforced concrete at the ends of the 37-ft. deck.

Programme of Construction.—Only one caisson is being built at present, though it is expected that two will be provided for the operation of the canal. The first is to be completed about September, 1914, and towed to the Isthmus for test at the lower end of Miraflores Locks. The test may suggest modifications; if not, the second caisson will be constructed like the first. The patterns tor all the castings in the structure will become the property of the Isthmian Canal Commission on acceptance of the caisson, and will be delivered with it. Fabrication and erection of the first caisson are being supervised at the plant of the contractor by Mr. Lewis A. Mason, assistant engineer, who was associated with Mr. Henry Goldmark, designing engineer, in working out the design, plans, and specifications.

A LARGE CENTRAL HEATING PLANT.

About 22,000 tons of coal is the annual consumption of the central heating plant of the University of Wisconsin, at Madison, Wis. Only 10% of the total fuel is chargeable to power uses. All power exhaust, together with low-pressure live steam, is used for heating. At present 42 buildings are heated from the central plant, including practically all of the University buildings and the United States Forest Products Laboratory. The distribution system includes 2 miles of tunnel and 1 mile of conduit. The maximum pipe size is 16 in.; on this a total thickness of 3 in. of 85% magnesia insulation is used. The heating pressure is 5 to 10 lb., and no difficulty in maintaining pressure at the receiving end has been experienced.

The world's production of copper, during 4 years, as given in a recent issue of the "Engineering and Mining Journal," is as follows, quantities in metric tons:—

Country.	1910.	1911.	1912.	1913.
United States	492,712	491,634	563,260	555,990
Mexico	62,504	61,884	73,617	58,323
Canada	23,810	25,570	34,213	34,880
Cuba	3,538	3,753	4,393	3,381
Australasia	40,962	42,510	47,772	47,325
Peru	27,375	28,500	26,483	25,487
Chile	38,346	33,088	39,204	39,434
Bolivia	3,212	2,950	4,681	3,658
Japan	50,703	52,303	62,486	73,152
Russia	22,700	25,747	33,550	34,316
Germany	25,100	22,363	24,303	25,308
Africa	15,400	17,252	16,632	22,870
Spain and Portugal	51,100	52,878	59,873	54,606
Other countries	24,888	26,423	29,555	27,158
Totals	882,351	886,855	1,020,022	1,005,978

SUMMARY OF TESTS OF BOND BETWEEN CONCRETE AND STEEL.

The usefulness of reinforced concrete as a structural material depends on the strength and permanency of the bond between the concrete and the reinforcing metal, and for this reason bond resistance has received much attention from engineers and experimenters. It is said that Thaddeus Hyatt made tests to determine the bond between concrete and iron bars as early as 1876. During the past decade numerous bond tests have been reported. These tests have been characterized by a lack of uniformity in the form of the test specimen and in the methods of conducting the tests, as well as by the wide variations in the values reported for bond resistance. In nearly all the tests thus far published values of maximum bond resistance only have been given. These test results and the discussions called forth by them have furnished the basis for a great variety of opinions as to the value of bond resistance. Many explanations of the source and nature of bond resistance have been given. Various methods have been advocated for increasing bond resistance and numerous devices have been employed for this purpose.

Present practice is fairly standardized as to the bond stresses to be used in designing, but a rational basis for the stresses used is lacking and there is a great diversity of practice in the methods of calculating these stresses. There are many phases of bond action which are not now understood. It is evident that the distribution of bond stress in reinforced concrete members under load and the nature and value of bond resistance under given conditions may well be the subject of experimental investigation.

The tests reported in a bulletin, entitled "Tests of Bond between Concrete and Steel," recently issued by the Enginering Experiment Station of the University of Illinois, were undertaken with a view to securing additional information on the nature of the bond resistance of reinforcing bars in concrete, to determining values of bond resistance for a wide range of conditions, and to studying bond action in specimens of different forms. Tests were made on pull-out specimens and on reinforced concrete beams. In both forms of specimen attention was given to obtaining accurate measurement of the slip of bar through the concrete as the loading progressed. In many of the beam tests the slip of bar at various points along its length was measured for different loads. In the discussion of bond resistance the load-slip-of-bar relation has been utilized to a considerable extent. These measurements are useful in indicating the distribution of bond stress. They are particularly significant in the beam tests. In a few of the beam tests the distribution of bond stress was studied by measuring the changes in the stress in the longitudinal reinforcement throughout the length. The values found for bond resistance and the relative bond resistance found in beam tests and pull-out specimens are also interesting features of the investigation.

The pull-out tests consisted in applying load to a short reinforcing bar embedded in a block of concrete. The concrete block was generally 8 in diam. and 8 in. long, with the bar embedded axially. In certain groups of tests these dimensions were varied. The size of bar used varied between ¼ in. and 1¼ in. The pull-out tests covered a wide range and included effect of dimensions of specimen, effect of form of bar, effect of conditions of storage, effect of age and mix, using both plain and deformed bars, effect of different methods of loading, bond resistance of concrete setting under pressure, effect of reapplied loads, comparison with the bond resistance of reinforced concrete beams, etc. The deformed bars used included most of the forms in use at the time the work was begun, but it should be noted that the tests with deformed bars were intended to bring out the action of the deformed bar as contrasted with the plain bar and not to determine the value of particular forms of bars.

A special effort was made to determine the behavior of beams subjected to high bond stresses. The beams tested were 8 by 12 in. in section with an effective depth of 10 in. The span length was generally 6 ft.; a few beams were tested with span lengths of 5 to 10 ft. All beams were tested with two symmetrical loads, generally at the one-third points of the span. With the exception of six tests, the longitudinal reinforcement consisted of a single bar of large diameter placed horizontally throughout the length of the beam. Both plain and deformed bars were used.

The tests were made in the laboratory of Applied Mechanics of the University of Illinois, and formed a part of the investigations of reinforced concrete and other structural materials which are being conducted by the Illinois Engineering Experiment Station. These tests cover the experiments which were designed with special reference to a study of bond between concrete and steel during the period of 1909-1912. This work was done by Duff. A. Abrams, Associate in Theoretical and Applied Mechanics, under the direction of A. N. Talbot, Professor in Charge of that Department. The tests covered a wide range of conditions and the results have a significant bearing on the nature of bond resistance, the action of bars of different forms under bond stress, and the behavior of beams subjected to high bond stresses. The load-slip determinations have given definite information on the nature and distribution of bond resistance. The following is a resumé of the principal observations and conclusions which have been stated and discussed in the text. Paragraphs 2 to 34 refer primarily to the results of the pull-out tests:—

(1) Bond between concrete and steel may be divided into two principal elements, adhesive resistance and sliding resistance. The source of adhesive resistance is not known, but its presence is a matter of universal experience with materials of the nature of mortar and concrete. Sliding resistance arises from inequalities of the surface of the bar and irregularities of its section and alignment together with the corresponding conformations in the concrete. The adhesive resistance must be overcome before sliding resistance comes into action. In other words, the two elements of bond resistance are not effective at the same time at a given point. Many evidences of the tests indicate that adhesive resistance is much the more important element of bond resistance.

(2) Pull-out tests with plain bars show that a considerable bond stress is developed before a measurable slip is produced. Slip of bar begins as soon as the adhesive resistance is overcome. After the adhesive resistance is overcome, a further slip without an opportunity of rest is accompanied by a rapidly increasing bond stress until a maximum bond resistance is reached at a definite amount of slip.

(3) The true relation of slip of bar to bond stress can best be studied by considering the action of a bar over a very short section of the embedded length. The difficulties arising from secondary stresses made it impracticable to conduct tests on bars embedded very short lengths. The desired results were obtained by varying the forms of the specimens in such a way that the effect of different combinations of dimensions could be studied.

(4) Pull-out tests with plain bars of the same size embedded different lengths furnish data which suggest

the values of bond resistance over a very short length of embedment, or indicate values of bond resistance which are independent of the length of embedment. Tests with bars of different size which were embedded a distance proportional to their diameters give the true relation when the effect of size of bar is eliminated. Two series of tests of this kind on plain round bars of ordinary mill surface gave almost identical values for bond resistance after eliminating the effect of length of embedment and size of bar, and we may consider that these values represent the stresses which were developed in turn over each unit of area of the embedded bar as it was withdrawn by a load applied by the method used in these tests. These tests showed that for concrete of the kind used (a 1:2:4 mix, stored in damp sand and tested at the age of about 60 days) the first measurable slip of bar came at a bond stress of about 260 lbs. per sq. in., and that the maximum bond resistance reached an average value of 440 lbs. per sq. in. If we conclude that adhesive resistance was overcome at the first measurable slip, it will be seen that the adhesive resistance was about 60 per cent. of the maximum bond resistance. This ratio did not vary much for a wide range of mixes, ages, size of bar, condition of storage, etc.

(5) Sliding resistance reached its maximum value for plain bars of ordinary mill surface at a slip of about 0.01 in. The constancy in the amount of slip corresponding to the maximum bond resistance for a wide range of mixes, ages, sizes of bar, conditions of storages, etc., is a noteworthy feature of the tests. With further slip the sliding resistance decreased slowly at first, then more rapidly, until with a slip of 0.1 in. the bond resistance was about one-half its maximum value.

(6) Pull-out tests with plain round bars show end slip to begin at an average bond stress equal to about one-sixth the compressive strength of 6-in. cubes from the same concrete; the maximum bond resistance is equal to about one-fourth the compressive strength of 6-in. cubes. These values were about the same for a wide range of mixes, ages and conditions of storage. In terms of the compressive strength of 8 by 16-in. concrete cylinders these values would be about 13 per cent. for first end slip and 19 per cent. for the maximum bond resistance.

(7) The tests indicate that bond stress is not uniformly distributed along a bar embedded any considerable length and having the load applied at one end. Slip of bar begins first at the point where the bar enters the concrete, and the bond stress must be greater here than elsewhere until a sufficient slip has occurred to develop the maximum bond resistance at this point. Slip of bar begins last at the free end of the bar. After slip becomes general, there is an approximate equality of bond stress throughout the embedded length.

(8) Small bars gave a bond resistance somewhat higher than the large bars during the early stages of the test. This was probably on account of greater irregularity of section and alignment of the smaller bars. The maximum bond resistance was not materially different for bars of different diameters.

(9) Computations based on the elastic properties of the materials indicate that in the pull-out tests the tensile deformation in the bar had a much greater effect on the amount of bond stress which permitted a given slip of bar than had the compressive deformation in the concrete block in which the bar was embedded.

(10) Rusted bars gave bond resistances about 15 per cent. higher than similar bars with ordinary mill surface.

(11) The tests with flat bars showed wide variations of bond resistance and were not conclusive. Square bars gave values of unit-stress about 75 per cent. of those obtained with plain round bars.

(12) T-bars gave lower unit bond resistance than plain round bars, but gave about double the bond resistance per unit of length that was found for the plain round bars of the same sectional area.

(13) With polished bars the bond resistance is due almost entirely to adhesion between the concrete and steel. Numerous tests with polished bars embedded in 1:2:4 concrete and tested at 60 days indicated a maximum bond resistance of about 160 lbs. per sq. in., or about 60 per cent. of the bond resistance of bars of ordinary surface at small amounts of slip. This value agrees closely with tests reported elsewhere, and apparently represents the value of the tangential adhesion between any clean steel and concrete of this quality. The sliding resistance of polished bars was very low.

(14) Tests with polished bars with wedging and non-wedging tapers showed that adhesion was broken for both types of bar at about the same bond stress as in the polished bars of uniform section.

(15) The tests with polished bars with wedging taper showed that after the adhesion was broken a considerable movement of the bar (as much as ¼ in. with the smallest tapers) was required before the bond resistance again reached the amount which was at first carried by the adhesive resistance. The amount of movement necessary to restore the bond stress to the value of the original adhesive resistance was inversely proportional to the amount of taper. This indicates that a definite normal compression must be developed in the surrounding concrete before a longitudinal component equivalent to the original tangential adhesion is produced.

(16) It was noted in the tests with plain bars that sliding resistance was due to inequalities of the surface of the bar and to irregularities of its section and alignment. The projections on a deformed bar give an exaggerated condition of inequality of surface or irregularity of section. Adhesive resistance must be destroyed and the usual sliding resistance largely overcome and the concrete ahead of the projections must undergo an appreciable compressive deformation before the projections on a deformed bar become effective in taking bond stress. The tests indicate that the projections do not materially assist in resisting a force tending to withdraw the bar until a slip has occurred approximating that corresponding to the maximum sliding resistance of plain bars. As slip continues a larger and larger portion of the bond stress is taken by direct bearing of the projections on the concrete ahead.

(17) In determining the comparative merits of deformed bars, the bar which longest resists beginning of slip should be rated highest, other considerations being equal. The bond stresses developed at an end slip of 0.001 in. furnished the principal basis of comparison for the different types of deformed bars. At an end slip of 0.001 in. 12 sets of deformed bars of ¾-in. and larger sizes embedded 8 in. in 1:2:4 concrete, tested at about 2 months, developed an average bond resistance of 318 lbs. per sq. in., 4 per cent. higher than the corresponding value for plain bars. At this stage of the test, two sets of deformed bars gave practically the same bond resistance, five sets gave lower values, and five sets higher values than the plain rounds. At an end slip of 0.01 in., corresponding to the maximum bond resistance of plain bars, the average bond resistance of the 12 sets of deformed bars was 445 lbs. per sq. in., 10 per cent. higher than plain rounds. At this stage of the test two sets gave about the same values, two sets gave lower values, and eight sets gave higher values than the plain bars. The hooping used in these specimens had a marked effect in

increasing the bond resistance, even at small amounts of slip.

(18) The concrete cylinders of the pull-out specimens with deformed bars were reinforced against bursting or splitting, because it was desired to study the load-slip relation through a wide range of values. The bond stresses corresponding to an end slip of 0.1 in. are the highest stresses reported for the deformed bars. In only a few tests was the maximum bond resistance reached at an end slip less than 0.1 in. It should be recognized that, in general, the bond stresses reported for deformed bars at end slip of 0.05 and 0.1 in., could not have been developed with bars embedded in unreinforced blocks. These high values of bond resistance must not be considered as available under the usual conditions of bond action in reinforced concrete members. In the tests in which the blocks were not reinforced, evidence of splitting of the blocks was found at end slips of 0.02 to 0.05 in.

(19) The normal components of the bearing stresses developed by the projections on a deformed bar may produce very destructive bursting stresses in the surrounding concrete. The bearing stress between the projections and the concrete in the tests with certain types of commercial deformed bars was computed to be from 5,800 to 14,000 lbs. per sq. in. at the highest bond stresses considered in these tests. For bars having projections of different heights and spacing, the bearing stresses on the projections at the highest bond stresses considered were inversely proportional to the bond stress which had been developed by the bar at an end slip of 0.01 in., the slip at which the projections were beginning to be effective. These considerations show that the ratio of the area of the projections measured at right angles to the bar to the superficial area of the bar in the same length is the proper criterion for judging of the effective bond resistance of a deformed bar. In some forms of bar the bearing stresses must have been much higher than the values given above. The large slip and the high bearing stresses developed in the later stages of the tests show the absurdity of seriously considering the extremely high values that are usually reported to be the true bond resistance of many types of deformed bars.

(20) Round bars with standard V-shaped threads gave much higher bond resistance at low slips than the commercial deformed bars. The average bond resistance at an end slip of 0.001 in. was 612 lbs. per sq. in. The maximum bond resistance was 745 lbs. per sq. in. These were the only deformed bar tests in which failure came by shearing the surrounding concrete.

(21) In a deformed bar of good design the projections should present bearing faces as nearly as possible at right angles to the axis of the bar. The areas of the projections should be such as to preserve the proper ratio between the bearing stress against the concrete ahead of the projections and the shearing stress over the surrounding envelope of concrete. Failure by shearing of the concrete should be avoided. The tests indicate that the areas of the projections measured at right angles to the axis of the bar should not be less than, say, 20 per cent. of the superficial area of the bar. A closer spacing of the projections than is used in commercial deformed bars would be of advantage. Advocates of the deformed bar would do well to recognize the fact that in a deformed bar which may be expected to develop a high bond resistance, a certain amount of metal must be used in the projections which probably will not be available for taking tensile stress.

(22) The 1-in. twisted square bars gave a bond resistance per unit of surface at an end slip of 0.001 in., only 88 per cent. of that for the plain rounds. Following an end slip of about 0.01 in., these bars showed a decided decrease in bond resistance, and a slip of 5 to 10 times this amount was required to cause the bond resistance to regain its first maximum value. After this, the bond resistance gradually rose as the bar was withdrawn. Some of the bars were withdrawn 2 or 3 in. before the highest resistance was reached. The apparent bond stresses at these slips were very high; but, of course, such stresses and slips could not be developed in a structure and could not have been developed in the tests had the blocks not been reinforced against bursting. Such values are entirely meaningless under any rational interpretation of the tests.

(23) The load-slip curves for twisted square bars are similar to those for polished bars with wedging taper. The twisted bar is essentially a combination of the wedging and non-wedging taper. As the bar is drawn through the concrete the wedging tapers are drawn more firmly against the concrete ahead, while at the same time the non-wedging tapers are separated from the concrete with which they were originally in contact. The drop in the load-slip curves after an end slip of about 0.01 in. shows that the separation of about one-half of the surface of the bar from its original contact and the continued sliding of the flatter portions of the bar, until a large slip has occurred, have a greater influence in reducing the average bond resistance than the increased bearing of the wedging tapers has in raising the bond resistance. The results found with the twisted square bar do not justify its present widespread popularity as a reinforcing material.

(24) The tests with plain round bars anchored by means of nuts and washers and with washers only showed that the entire bar must slip an appreciable amount before these forms of anchorage come into action. Anchorages of the dimensions used in these tests did not become effective until the bar had slipped an amount corresponding to the maximum bond resistance of plain bars. With further movement the apparent bond resistance was high, but was accompanied by excessive bearing stresses on the concrete.

(25) The load-slip relation for bars anchored by means of hooks and bends was not determined. The high resistance given in these tests was probably a result of the bearing stresses developed in the concrete ahead of the bends.

(26) Tests on specimens stored under different conditions indicate that concrete stored in damp sand may be expected to give about the same bond resistance and compressive resistance as that stored in water. Water-stored specimens gave values of maximum bond resistance higher in each instance than the air-stored specimens; the increase for water storage ranged from 10 to 45 per cent. The difference seemed to increase with age. The presence of water not only did not injure the bond for ages up to three years, but it was an important factor in producing conditions which resulted in high bond resistances. However, it was found that specimens tested with the concrete in a saturated condition gave lower values for bond than those which had been allowed to dry out before testing. The bars in specimens which had been immersed in water as long as three and one-half years showed no signs of rust or other deterioration.

(27) Specimens made out-doors in freezing weather, where they probably froze and thawed several times during the period of setting and hardening, were almost devoid of bond strength.

(To be continued.)

Coast to Coast

Toronto, Ont.—The Toronto Hydro-Electric Commission sustained a deficit of $1,600 for the past month.

Calgary, Alta.—A report has been presented by the city commissioners to the Calgary city council showing the surplus for 1913 for the Calgary Electric Railway to be $177,000.

Winnipeg, Man.—Another report, submitted recently by J. G. Glassco, superintendent of the Winnipeg light and power department, indicates a surplus amounting to $81,897.45 for the year ending April 30, 1914.

Winnipeg, Man.—In the und rakings which Winnipeg has planned for 1914, there will be involved an expenditure of $10,000,000. In addition to this, the Greater Winnipeg Water District board will spend $2,000,000.

Montreal, Que.—It is reported from headquarters at Montreal that the G.T.R. Railway Company is now carrying passengers over an all-rail route from Fort William, Ont., to Prince George, B.C., a distance of 1,729 miles.

Port Arthur, Ont.—A recent statement made by the public utilities commissioner of Port Arthur shows that in Port Arthur there are now 2,224 street lights. Addition to the city's street lighting system is being made continuously.

London, Ont.—A report from London announces that another gas gusher has been struck close to the great Fairbanks gusher recently struck; and that the new well is flowing at a rate of 500,000 feet per day. The drill had only reached the depth of 1,800 feet.

Maple Creek, Sask.—The Coste-McAuley syndicate has filed for the gas and oil rights on 80,000 acres of land situated from 60 to 65 miles north of Maple Creek. It is in this area that the company will bore for the gas, with which it hopes to supply the cities of Saskatchewan.

Ottawa, Ont.—A report from Ottawa advises that construction work on the National Transcontinental Railway has reached a stage of practical completion. All that remains to be done is some additional ballasting and filling and the erecting of a few stations, which are to be completed by October 1.

Saskatoon, Sask.—A new system of electric lights is being tested at Saskatoon. High power nitrogen filled lamps are being suspended from the tops of trolley poles; and, should these prove more efficient and more economical, it is intended to place the lamps on most of the main thoroughfares of the city.

Regina, Sask.—The city council of Regina has approved the programme of this year's civic construction work recently recommended by the city commissioners, and has passed the by-laws necessary to legalize the flotation of treasury bills to the extent of $1,250,000, of which $500,000 is to be issued immediately.

Hamilton, Ont.—Hydro-Electric street lighting was inaugurated at Hamilton on July 1. It is estimated by the city works department that lighting under hydro management will cost $98,000 per year, or $49,000 per half-year during the time that the lights wou'd be mostly in service. The department has expropriated $58,000 for the half-yearly expense.

Fort William, Ont.—Construction work has started on the big turning basin in the Fort William harbor, 5 miles up from the mouth of the Kaministiquia River. Two clam shell dredges are at present engaged in taking out loose earth; and in about two weeks' time the large dipper dredges of the Great Lakes Dredging Co., will also be employed. The construction of the turning basin is a large undertaking. Over 35 acres of solid earth will have to be removed before the basin is finished; and it will take some 2 years to complete the work.

Calgary, Alta.—An announcement was made last week by City Engineer Craig of Calgary, to the effect that actual construction work on the new bridges proposed at Calgary will commence within a month or 6 weeks. About 6 weeks ago, the by-laws providing for the bridges were passed; and since that date, the engineer's department has been employed on the necessary surveys. Construction will begin at the Louise Street bridge, since more time will be needed to complete the surveys for the Centre Street structure.

St. John, N.B.—Recently a shipment of steel for the new bridge being constructed by the Dominion Bridge Company over the reversible falls, is reported as having arrived in St. John; and the preliminary work of placing the first piece in position is proceeding under the supervision of Engineer Springer. The large granite blocks upon which the new pier will be erected have been placed on the bed of concrete; and this part of the contract will be completed very shortly. The steel work will then be advanced rapidly.

Victoria, B.C.—A recent announcement from Victoria states that satisfactory progress is being made with the construction of the concrete tank which will be a part of the northwest sewer system, and into which sewerage will be drained from the area lying north of the Burnside Road and thence pumped into the system which will carry the sewerage across the Victoria Arm and across to the outlet at Macaulay Point. The tank is being made especially strong to support the roadway beneath which it is being constructed.

Ottawa, Ont.—The construction of both the bridge across the Rideau Canal to Ottawa East from Pretoria Avenue and the bridge across the Rideau River at Billings' Bridge, is being delayed. In the former instance, the officials of the Ottawa Electric Railway will not consent to run cars over a low level lift bridge, the plans for which are now being prepared by the city engineer at a cost of $120,000; while, in the latter, the county has refused to bear half the cost of construction, and an agreement has yet to be reached as to the division of cost between the city and county.

Vancouver, B.C.—Officials of the engineering department of the Canadian Northern Pacific Railway have announced that track-laying will be resumed on that road from Kamloops to a point 28 miles west where the right-of-way crosses the Thompson River. The track construction will be delayed at the Thompson River until a bridge has been completed across it, when another section of the road will probably be built and the uncompleted portion of the work between Cisco and Kamloops somewhat diminished. The steel for the bridge across the Thompson has already been fabricated, and as soon as the rails reach the river, work will be commenced and rushed ahead on the erection of this structure.

Medicine Hat, Alta.—In the course of a few weeks Medicine Hat will have a most up-to-date and modern telephone system, differentiating from the present one in that it will be large enough to accommodate several times its capacity. For some time contractors have been at work on the installation, a new building, for this purpose only, being part of the plans. Contractors are engaged in the construction of the building and also on 125,000 feet of underground conduits; and it is expected that September will see the city served with the latest automatic telephone system. Some 2,000 of the new phones have already arrived for installation, there being room for 10,000 if required in the near future. Every part of the city will have adequate connection; and no poles will be used except in the lanes.

Winnipeg, Man.—An expenditure for the month of July amounting to $168,470, has been passed by the administration board of the Greater Winnipeg Water District. Items of expenditure have been placed as follows: salaries and wages, $13,000; supplies and equipment, $3,000; railway ties contract, $32,300; steel rails, $59,000; steel splice bars, $3,310; railway construction, $54,000; residences for divisional engineers, $2,150; switches, frogs, and track accessories, $1,710. It is estimated that an expenditure of $500,000 will be passed for the month of August, though the total outlay is placed at $522,580.29 Plans for the aqueduct line beyond range 7 will be completed and work on them is now being advanced rapidly. This will conclude the determination of the exact line to be followed east as far as the Whitemouth River, which will be over half the way to Indian Bay at Shoal Lake. The route will not go in a straight line but will have numerous angles and curves as has the sanctioned plan from the Transcona reservoir site to the end of range 7, 24 miles east of the city.

PERSONAL.

CAMPBELL M. HUNTER A.M.Inst.C.E., F.R.G.S., of the firm of Thompson and Hunter, geologists specializing in petroleum investigations, is investigating oil possibilities in the Province of Alberta.

LUCIUS E. ALLEN, A. B., C.E., consulting engineer of Belleville, Ont., sails for Europe on July 11th, for the purpose of making an investigation and study of Continental methods and materials used in good roads and pavements.

H. T. CROSBIE, town engineer of Yorkton, Sask., read a paper at the recent municipal convention in Moose Jaw, entitled "Engineering Advice to Villages About to Enter the Town Estate." Mr. Crosbie dealt with the subjects of water supply, sewerage system, electric light, sidewalks and boulevards and town planning.

A. N. JOHNSON, M.Am.Soc.C.E., has resigned as State Highway Engineer of Illinois to accept a position with the Bureau of Municipal Research, New York City. Mr. Johnson graduated in civil engineering at the Lawrence Scientific School, Harvard University, in 1894. He was an instructor at Harvard in 1895 and 1896, and then for two years was Assistant Engineer of the Massachusetts Highway Commission. From 1898 to 1905, Mr. Johnson was State Highway Engineer of Maryland. For a year he was Chief Engineer of the United States Office of Public Roads, Washington, D.C., and since 1906 has been State Highway Engineer of Illinois.

OBITUARY.

The death occurred in Toronto recently of Chas. R. Rundle, for many years prominently engaged in contracting work.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

The following engineers were elected to membership in the Canadian Society of Civil Engineers at a meeting of the Council in June:—

Duncan McMillan, district engineer's office, Canadian Northern Railway, Victoria, B.C.; Robt. H. Parsons, superintendent of municipal electric light, power and pumping plant, Edmonton, Alta.; A. K. Robertson, chief engineer, McAlpine, Robertson Co., Vancouver, B.C.; C. B. Thorne, chief engineer, Riordon Pulp and Paper Co., and manager Hawkesbury branch.

At the same election the following were transferred from the class of associate member to that of member:—

Geo. E. Bell, western manager, Dominion Bridge Co., Limited, Winnipeg; Wm. M. Edwards, consulting engineer and professor of municipal engineering, University of Alberta; E. A. James, consulting engineer, Toronto.

At a previous meeting, April, the newly-elected members were G. C. Clarke, chief engineer, Fraser, Bruce and Co., New York City; Ernest Davis, hydrographer, Water Rights, Department of Lands, British Columbia Government, Victoria, B.C.; Geo. R. Heckle, managing director, Walker and Co., Ambursen Hydraulic Construction Co. and Reinforced Concrete Pile Co., Montreal; H. E. M. Kensit, city commissioner, Prince Albert, Sask.

The transfers from class of associate member to that of members consisted of C. B. Brown, prin. asst. engineer, eastern lines, Canadian Pacific Railway, Montreal; R. J. Gibb, sewer and waterworks engineer, Edmonton, Alta.; J. H. Holliday, district engineer, Transcontinental Railway, L'Islet, P.Q.; W. Hollingworth, deputy city engineer, Hamilton; Chas. M. Morssen, president and consulting engineer, Atlas Construction Co., Montreal; F. H. Peters, commissioner of Irrigation and chief engineer, Department of the Interior, Irrigation Office, Calgary; C. W. P. Ramsay, engineer of construction, Canadian Pacific Railway, Montreal; H. P. Rust, prin. asst. engineer, Viele, Blackwell and Buck, consulting engineers, New York City.

At a March meeting Messrs. E. A. Cleveland, of Cleveland and Cameron, Vancouver, B.C., and Fred C. Kunz, consulting engineer, Philadelphia, Pa., were elected members.

COMING MEETINGS.

UNION OF CANADIAN MUNICIPALITIES.—Annual Convention to be held in Sherbrooke, Que., August 3rd, 4th and 5th, 1914. Hon. Secretary, W. D. Lighthall, Westmount, Que. Assistant-Secretary, G. S. Wilson, 402 Coristine Building, Montreal.

WESTERN CANADA IRRIGATION ASSOCIATION.—Eighth Annual Meeting to be held at Penticton, B.C., on August 17, 18 and 19. Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

AMERICAN PEAT SOCIETY.—Eight Annual Meeting will be held in Duluth, Minn., on August 20th, 21st and 22nd, 1914. Secretary-Treasurer, Julius Bordollo, 17 Battery Place, New York, N.Y.

CANADIAN FORESTRY ASSOCIATION.—Annual Convention to be held in Halifax, N.S., September 1st to 4th, 1914. Secretary, James Lawler, Journal Building, Ottawa.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown, Indianapolis, Ind., Secretary.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.—11th Annual Convention; 5th American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau St., New York, N.Y.

Volume 27. Toronto, July 16, 1914

Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

WATER SUPPLY FOR CITIES AND TOWNS

AN OUTLINE OF THE PROBLEMS CONNECTED WITH WATERWORKS CONSTRUCTION AND VALUABLE HINTS AS TO THEIR SOLUTION.

By BERNARD E. T. ELLIS, C.E.,
Oborn and Ellis, Consulting Civil Engineers, Toronto and Hamilton.

AMONG the problems which attend the establishment of a water supply for a community the first, and often the most important, is its source, particularly in the case of towns and cities that are not so favored by nature as to be able to secure an ample and safe supply from adjacent lakes or rivers, but have to resort to wells, collecting grounds, etc.

The first step the engineer is called upon to decide is the selection of a suitable watershed and site for the proposed works, including the dam and reservoir. Since we depend solely upon rain for our supply of water, after these selections have been made it is necessary to find out exactly how much rain actually falls on the contemplated watershed drained by the stream which is to feed the impounding dam. To do this, rain gauges must be fixed on the watershed and from these an estimate made of the rainfall. After comparing them with any existing rain gauge records which have been kept over a number of years in close proximity to the proposed site, the engineer should be able to strike a fair average of the rainfall. The longer the period taken, the better and more satisfactory average results will be obtained. From these records an estimate of the quantity available for storage can be calculated allowing, of course, for losses on the average rainfall due to evaporation, percolation, and absorption, which allowance can only be estimated from previous experience on similar gathering grounds, and practical experience of the engineer. After computing the available supply for storage, the available yield in gallons per day is arrived at. An excellent check on the amount—a really better method to obtain the actual supply—lies in the use of stream gauges. They should be placed, wherever possible, in the feed channel supplying the impounding dam, and, when fitted with an automatic recorder, render the operation a simple and accurate test for the actual yield.

In most cases part of this supply will have to be liberated to supply rivers, etc., for compensation water (usually fixed at ⅓) and this must be deducted before deciding upon the average available daily supply.

The size of the impounding dam should be next settled. The late Thomas Hawkesley's well-known formula, which gives the number of days' storage required, taking for safety the mean annual rainfall for the three driest years, is recommended. Then, after levelling and contouring the site, the engineer can determine the height and dimensions of the dam to impound the required number of gallons. The actual construction of the dam will depend largely on local conditions, especially as to material of which it will be constructed, but the ground should be carefully examined, trial holes sunk, plans prepared showing all levels, etc., and geological formation before the actual locality and line of the proposed structure can be definitely settled.

In this paper it is not proposed to enter into the actual design of the dam and the many calculations required as the subject cannot be treated properly in the limited space, but on its stability the engineer is very often confronted with serious difficulties, and the most important points for his careful consideration will be the foundations, stability of walls, and a properly designed overflow to take off the flood water. A dam may fail by overturning, crushing, sliding, shearing, or by rupture due to tension, and to safely guard against all these causes of failure the section of the wall must be such that the lines of resultant pressure, both when the dam is full or empty, must fall within the middle third of any horizontal joint, in order that the maximum pressure on the foundation will never exceed certain fixed limits of safety. The friction between any horizontal layers, into which the dam may be divided, and also between the main walls and their foundation must be sufficient to prevent any sliding taking place. The ideal and safe cross-section of wall is the one which is constructed of sufficient dimensions to safely withstand all these pressures. After they have been properly calculated, the method adopted by the author in calculating the required sections for the design of the walls is by mathematics, and on completing same, he re-checks graphically, so that the line of pressure must fall within the middle third.

A considerable economy can be made if the site of the valley across which it is proposed to construct the dam is narrow, by making the dam curved and reducing the section, but the author does not recommend, from a stability standpoint, a greater radius than 300 feet being actually constructed. One of the main points, frequently overlooked, and upon which the stability of the dam and safety of the system so largely depend, is the provision of a sufficiently large overflow to amply take care of all likely flood water, as without such the works may be seriously damaged and unnecessary trouble and expense incurred which, at little first cost, could easily be provided for. From the author's own observations and experience he advises a 3 to 4-ft. length of weir to every 100 acres of watershed, fixing the maximum height, in all cases, to which the water is allowed to rise above the crest of the weir at 1 ft. 6 in. to 2 ft.

Purification of Water.—The methods adopted to purify water for domestic consumption are æration, subsidence, precipitation, straining, and filtration.

Aeration or oxidation is sometimes adopted to get rid of certain impurities in the water, such as dissolved sulphuretted hydrogen, exposure to the atmosphere in thin sheets or sprays, has the effect of also softening hard waters, by releasing the loosely combined carbonic acid and precipitating the carbonate of lime. This process is very rarely adopted, the chief objection being vegetable growth, but the action of oxygen in the atmosphere on water in rivers or channels, certainly gradually oxidizes the organic impurities, and in time renders them innocuous and the water more palatable.

Subsidence.—This procedure generally takes effect in storage reservoirs and depends solely on the specific gravity or fineness of the matter in suspension being deposited.

Precipitation.—Water, especially when obtained from bore holes (see later) is often hard and sometimes it is of such a nature that after standing it becomes slightly discolored, due generally to deposit of iron. Now that the question of an ample and suitable water supply plays such an important part in our present-day manufacturing industries, it is essential from this standpoint, as well as from the domestic one, that the supply should be softened and purified to be beneficial for all concerned. Without entering into any details of any individual water-softening process, the general outline of the cheapest and universal methods and materials adopted in most cases, may be briefly given. Caustic lime is one of the most economical precipitants and the *modus operandi* is to add a certain quantity of lime to a measured volume of water in a tank or vessel, to form lime water. The clear fluid is then drawn off by a float pipe into another tank and mixed with the water to be softened. The result is the formation of carbonate of lime, which is precipitated along with the carbonates already in solution. In some plants it is an advantage to discharge "purified" generated carbonic acid gas into the main delivery pipe from the softening tanks. If, at the expiration of the time allowed for settling, there are any particles of lime left in the water, whether visible or otherwise, they unite with the carbonic acid gas and form a soluble carbonate which is taken up by the water and does not make any appreciable effect on the hardness of the softened water.

Straining and Filtration.—Straining water through fine screens of brass or copper set in wooden frames has proved satisfactory, and in some cases the author recommends their use in reservoirs, as, when properly supervised and cleansed by a jet of water, they arrest and intercept large quantities of floating suspended matter. Gravity or sand filters have been adopted in the past, owing to the general opinion that the slow gravitation of water through layers of sand, polarite, spongy iron and other media removes the suspended matter and purifies the water better than any other system, and the author under this head intends to illustrate the many advantages obtained by the installation of suitable mechanical filters in preference to the gravity type, especially in cases of large cities. A mechanical plant does not require the extensive area of a gravity bed; consequently there is a great saving in purchasing suitable land. A million gallons per day can be treated on gravity filters on an area of approximately 2,000 sq. yd., whereas the same quantity could be mechanically treated on a space of 60 to 70 sq. yd. This is a considerable saving, especially in works of any magnitude, such as required for large cities. Again, whatever a filter bed extracts it retains and the better the filtering material the sooner it becomes clogged and requires cleansing. Therefore, ease and rapidity of cleansing should play an important point before the engineer decides on the class of filters he should adopt.

The gravity beds, when downward filtration is adopted, requires the constant attention and removal of the top layer of sand, containing the perceptible suspended matters. If the sand is costly and has to be washed, an expensive sand-washing machine is centrally installed which necessitates a cleansing gang continually employed to wash the beds in rotation. On large filtration areas this is a very costly maintenance item.

The cleansing of the mechanical filters is simply accomplished by upward or reversed flow of water, aided by the complete agitation of the filtering media by revolving arms, and the greater the amount of agitation within the bed of filtering material, the more rapid and effectual is the cleansing. The actual time taken in cleansing one of these filters varies from 3 to 5 minutes. For several obvious reasons the filtered water should only be used for cleansing purposes, as the impurites of unfiltered or raw water would collect at the bottom for the time being, and would have to be removed before considered fit for use.

A mechanical filtration plant capable of dealing with 5,000,000 gal. per day should take approximately 1½ hours to clean, using about one gallon to every 300 gallons of filtered water. Cleansing in mechanical filters for successful results should be accomplished every two days, which goes to prove that the filter is doing efficiently that which it is intended for. Another big advantage of mechanical filtration over sand filtration lies in the compactness of the plant, which facilitates better and cheaper maintenance, also a more complete and concentrated control over the feed pipes to the service reservoir.

It has been found and adopted in practice that the introduction of aluminum sulphate is very beneficial from two important aspects: (1) It acts as a coagulant causing minute particles to unite and become one large particle; (2) being converted into aluminium hydrate, a gelatinous insoluble mineral matter is formed on the filter bed, being impervious to micro-organisms, and having the power to extract coloring matter, adds materially to the filtering media, as the coloring is often due to dissolved vegetable matter and cannot be arrested in the finest filtering material unless in conjunction with precipitated aluminum-hydrate. This would not be feasible or workable in cleansing operations for gravitation or sand-bed filters.

There are several different mechanical filtration plants from Great Britain and the United States well represented on the Canadian markets, and the author advises any local authority who contemplates the installation of mechanical filters to place the scheme in the hands of an expert water engineer who can get out the necessary data and specifications for such an installation, and is in a better position to judge technically the merits and cost of such installations represented by the different companies who are invited to tender.

Service Reservoirs.—Service reservoirs are supplied direct from the impounding reservoir, or where filtration is necessary from the filter beds. Their use in water supply systems is to regulate the variation in daily consumption, and during accidents or break-downs to supply sufficient storage to meet the supply requirements. Their size, or storage capacity, depends on local conditions of the scheme, such as the distance from source of supply, single or duplicated feed pipes (especially important in case of a pumped supply). As a general rule, 2 to 3 days' storage capacity should meet all emergencies.

The site of reservoir should be at a sufficient elevation to give the required pressure on the mains and as close

as convenient to the district to be supplied. The actual construction of it depends on local conditions, both from a material and design standpoint. The author favors concrete construction with puddle clay backing and entirely covered in with arch construction, well ventilated and having at least 2 to 3 feet of earth filling above the roof to keep the water as cool as possible. The tank should be subdivided into at least two portions for cleansing purposes. The reservoir should be provided with ample arrangements for inspection and cleansing and the inlet, outlet and overflow pipes placed in the best position the local demands and requirements call for. After passing through the reservoir, the water should flow through a meter house constructed at the head of the main distribution pipes to the city and correct records kept by means of a meter recording automatically the daily consumption and delivery of water into the city at all hours of the day.

Wells.—A difficulty often arises in finding near a large town a suitable gathering ground. In such cases the engineer directs his attention to a source of supply from wells, if possible. In selecting the site and position of bore-holes, the engineer, if not conversant in practical geology, should engage the services of an expert geologist before finally selecting and commencing on a scheme. The preliminaries mentioned previously as regards rainfall calculations should be carefully and accurately taken and records kept. The construction for the bore-holes present very few engineering difficulties and is accomplished by the several drilling and deep-well boring outfits. The author has had experience in both the "free-falling tool" and the "slack rope" method, and can recommend both as worth consideration, the local conditions governing the final selection. Perhaps details the writer has at hand of the actual construction of a well and bore-hole for a large city in Great Britain will be of interest, as it gives an excellent idea of the usual procedure. The well was first constructed 8 feet inside diameter, 24 feet deep with 14 inches of best hard blue brick lining filled in behind with cement grout. The floor consisted of 18 inches of cement concrete. A circular cast iron standpipe, 29-in. bore 9 feet long with flanged end to which was fixed during boring operations two similar lengths bolted on with special short valve casting to facilitate the testing of the yield of the bore-hole at certain stages. The bore-hole for approximately 110 feet was 28 in. in diam. and lined with 25-in. bore steel tubes, the annular space being filled in with concrete and so lined to prevent the contamination by impure surface water. The boring was continued from the lining tubes with a 14-in. circular hole to the rock strata, a distance of approximately 600 feet, when the water-bearing strata was penetrated sufficiently for the following tests of the probable yield of water to be made. The previously mentioned valve at the top of the stand-pipe was closed and the brick well emptied of all water, carefully measured, and the water admitted by opening the valve on the standpipe. The time taken in filling the well was accurately measured as the water rose to the surface of the ground. This level was then taken as the rest level and surface pumping was continued to lower it. From these results the actual yield of water flowing into the well per hour was ascertained by hydraulic formula. The head on the valve being known, the yield in gallons per 24 hours could readily be calculated. In this particular case the above was considered sufficient to warrant the installation of the pumping and machinery plant. The actual yield from the bore-hole was almost 750,000 gal. per day.

Distribution.—It is always the aim of the engineer to install a gravitation system, not only from an initial outlay standpoint but also owing to maintenance cost. Providing the selected site for supply reservoir is situated at such an elevation as to give the minimum pressure for supply purposes, both for domestic and trade use, this can be adopted; but should it not be available, pumping machinery will have to be installed. It requires careful thought in designing a complete and suitable pumping plant of sufficient capacity to supply the maximum demand at all times and at the most economical cost, having in mind local conditions and requirements. The author has visited waterworks plant where considerable saving has been accomplished by means of syphons. A great deal of costly excavation can be saved by adopting syphons providing for practical working purposes the difference of elevation between the summit and level of water from which the supply is to be drawn does not exceed 25 feet (34 feet theoretically).

The syphon should be provided with an air pump attachment on the longer leg, and in all cases for proper and satisfactory results, sluice valves and cocks must be placed in proper positions.

Water is conveyed generally under pressure from the source of supply to the consumer and pipes are mostly used. They have been constructed in cast iron, wrought iron, steel, wood, and reinforced concrete. Whichever material is adopted the pipes should be properly calculated for diameter and thickness to give the delivery and strength required. The thickness of metal in pipes requires careful consideration and good judgment on the part of the engineer, as after calculations have been made, sufficient allowance must be made for imperfect workmanship, shocks in handling and laying, weight of earth and traffic, also the great strain to which pipes are subjected on the sudden closing and opening of valves. It is the author's practice in calculating the required thickness from formula to withstand the water pressure, to allow a high factor of safety to take care of the above-mentioned additional strains, and in no case using less than ⅝-in. in thickness whatever the calculations work out at.

A margin on the diameter should be allowed for possible corrosion. In specifying cast iron pipes, they should be cast vertically and dipped when hot into a hot bath of a solution consisting of asphalt, resin, pitch and linseed oil. A percentage of test bars 3 in. x 2 in. x 3 ft. 6 in. should be cast at the same time and tested for tensile strength and deflection. The following tests by Sir Frederick Bramwell, strikingly illustrate the increase in strength and density obtained by re-melting the metal before finally running:

Samples.	Tensile Strength per sq. in.
1st sample	7.5 tons
2nd sample, after 2 hours longer fusion	8.3 tons
3rd sample, after 1¾ hours longer fusion	10.8 tons
4th sample, re-melted with fresh pigs	11.0 tons
5th sample, after 4 hours longer fusion	18.5 tons
Maximum of 5th sample	19.6 tons

The strength at the spigot end is increased by casting an additional 6 in. or more beyond the finished length of the pipe, this having the effect of compressing the metal and permitting ash and air bubbles to rise into same, which extra length is finally cut off in the lathe and the pipe finished off to required dimensions. All pipes should be tested by oil or water (preferably the former) in a testing machine up to at least twice the pressure they will afterwards be subjected to before leaving the foundry.

Wrought iron and steel pipes have of late found favor amongst engineers, especially for large mains, because of their greater tensile strength and lightness over cast iron giving them many advantages in cases where weight and

strength are the main objects, but owing to the thickness and rapid corrosion of wrought iron and steel pipes the author thinks cast iron will be hard to displace for general use, as they are cheaper and more easily made Their greater thickness allows for corrosion, which overcomes to a certain extent one of the main difficulties in the upkeep and maintenance of water mains.

Pipe Jointing.—Cost and local ground conditions play an important point in settling the type of joint to be used, but the local custom of selecting spigot and socket joints in all horizontal positions (except for very high pressure pipes) and flanged joints where pipes are fixed vertically are so universally adopted that any description is not necessary. The author has used with success the turn and bored joint and can safely recommend same in bad situations, providing the pipes are laid in a straight line and an ordinary spigot and socket lead joint inserted every ninth or tenth pipe to allow for expansion in variable temperatures.

The laying of distributing pipes and mains presents very little difficulty, requiring engineering skill, especially in open ground. The only occasion where the work becomes intricate is in handling and laying large pipes in the centre of cities having their usual network of underground mains which have to be considered. On all pipe lines washout chambers should be built within reason, and especially at every depression, so that scouring out process may be easily accomplished, and an air valve placed at every high point to allow the imprisoned air to escape. Pipes should be laid true to line, grade, and on a good solid foundation, with particular care and attention paid for sufficient collar holes to facilitate and ensure the proper caulking of the joints. The mains, after being laid, should be subjected to proper tests and every length, when completed, should be closed by means of a blank socket, drilled and tapped to receive the connection pipe from the pressure pump, and a water pressure gauge showing the pressure registered in feet of water and lbs. per sq. in., with valves for safety, and lowering the pressure. An economical arrangement for testing the pipes is to commence laying, wherever practicable, from the source of supply, say reservoir, to the site of distribution.

All defects can be easily detected in the trench by careful observation and close attention to the indicator or pressure gauge, especially when pumping ceases. The most familiar defects are from weeping joints, split or cracked pipes and pinholes. The position of defect was marked on pipe, the pressure lowered, leakage made good, and the section re-tested. Weeping joints are generally easily put right by re-caulking. A split or cracked pipe requires more labor and attention, and in most cases its removal and replacement is the only satisfactory remedy. This can be accomplished in one of the following ways: (1) Burning out lead; (2) cutting out lead joint; 3) splitting off the socket; (4) replacing the whole pipe; (5) cutting the pipe, providing the defect is not too serious, the cracked portion taken out and a short piece cut to the required length inserted and jointed up by thimbles or sleeves. Pinholes in otherwise sound pipes may be drilled, tapped and plugged with brass or gun metal plugs.

Corrosion or rusting of pipes conveying water, both externally and internally, are serious items in the life of pipes supplying water as, although when properly coated with patent solution, corrosion is greatly reduced. But in time, unless properly inspected and removed, it takes effect, and although the danger of weakening the pipes is small, the real trouble lies in the contraction of the bore of the pipes, which diminishes their discharging capacity and reduces the working head.

Fire Service and Meters.—In conclusion the author would like to mention in connection with water supply for cities and towns—especially those in Canada—the absolute necessity of providing in all waterworks schemes an abundant supply to meet all the demands when called upon to save the destruction of lives and valuable property. This can only be successfully accomplished by the engineer making ample provision in the preparation of the scheme he is called upon to design; and by remedying the shocking waste of water in our cities through careless consumers who do not value or realize the expense a proper waterworks system entails to properly maintain out of the city's funds.

The advantage of having a powerful stream of water to be easily put into requisition to retard or prevent conflagration of buildings can be readily understood.

A little extra cost, if necessary arrangements are provided. in the original design of the waterworks, but may, as afterthoughts, prove an expensive addition.

The writer strongly recommends for use in case of fire, a surplus storage capacity over and above that required for general purposes, such storage to be of sufficient elevation to allow water being forced above the tops of the highest buildings in the cities, and also the arrangement and dimensions of •the mains and distributing pipes to be capable of permitting the maximum fire supply when the demand for water for other purposes is at its greatest. In order to render a fire service efficient, hydrants should be placed at the most convenient and important points on the system to ensure a maximum efficiency. They should be in sufficient number and, above all, easily accessible, but not in danger of frost.

The available head at any given point on the system is calculated by deducting the loss of head due to friction in the pipes from the statical head at that point. It can plainly be seen that such results only hold good on a thoroughly watertight system, and it is imperative for hydrant purposes to maintain pressure. The laying and testing of mains should have the strictest attention of the engineer.

With reference to the prevention of waste, this important point must sooner or later be taken up seriously by Canadian cities, especially where pumping is the means of supply. The author strongly favors the insertion of water meters on the distribution services as an excellent prevention against extravagance and thoughtless excess in consumption. There are certainly advantages and disadvantages, the latter applying especially to the cheaper class of dwellings, for such a step might mean reversing the conditions as they exist at present and economy being substituted for undue extravagance at the expense of cleanliness and health. On sanitary grounds this would be a great objection, but at any rate the writer strongly advocates the adoption of meters for trade and manufacturing purposes, and also the serious consideration of meters on residential property with modifications to offset the disadvantage mentioned above. There are two types of meters, the "positive" and the "inferential." The former records by clock mechanism on similar principle to that of a cylinder and side valve of a high-pressure steam engine, water alternately filling and emptying a vessel of known capacity. The latter mechanically registers the flow by recording the revolutions made by a wheel with vanes or discs attached, on the principle of the water-wheel or turbine in a small chamber. The engineer should select the one which combines accurate results with varied flows, simple and easy repairing, and does not interfere with loss of head in supply pipe.

SUMMARY OF TESTS OF BOND BETWEEN CONCRETE AND STEEL.

(Concluded from last issue.)

(28) Pull-out tests made at early ages gave surprisingly high values of bond resistance. Plain bars embedded in 1:2:4 concrete and tested at 2 days did not show end slip of bar until a bond stress of 75 lbs. per sq. in. was developed. Bond resistance increases most rapidly with age during the first month. The richer mixes show a more rapid increase than the leaner ones. The tests on concrete at ages of over one year showed that the bond resistance of specimens stored in a damp place may be expected ultimately to reach a value as much as twice that developed at 60 days.

(29) The load-slip relation of leaner and richer mixes was similar to that for 1:2:4 concrete. For a wide range of mixes the bond resistance was nearly proportional to the amount of cement used. This relation did not obtain in a mix from which the coarse aggregate had been omitted.

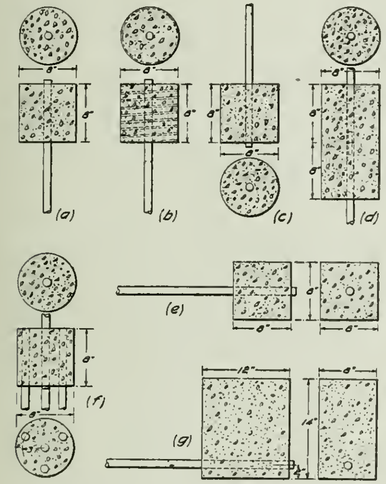


Fig. 1.—Types of Pull-out Specimens Used in the Tests.

(30) When the application of load was continued over a considerable period of time, or when the load was released and reapplied, the usual relation of slip of bar to bond resistance was considerably modified. The few tests which were made indicate that the bond stress corresponding to beginning of slip is the highest stress which can be maintained permanently or be reapplied indefinitely without failure of bond. The effect of continued and repeated load, impact, etc., may well be the subject of further experimental study.

(31) Little difference was found in the pull-out tests whether the load was distributed over the entire face of the block or over a narrow ring at the centre of the block or around the edge of the face of the block.

(32) Specimens molded in a horizontal position gave lower bond resistance than those molded in a vertical position; when settlement of the bar with the settlement of the concrete was entirely prevented, the bond resistance was reduced to about 60 per cent. of that found for similar specimens which were molded with the bars in a vertical position. Plain bars tested by being pulled in the same or the opposite direction from the settlement of the concrete during setting gave about the same bond resistance, but in the tests of certain deformed bars this was not true.

(33) The term "autogenous healing" is used to designate phenomena observed in pull-out tests and in compression tests of concrete cylinders in which the hardening of the concrete was interrupted by loading the specimen at early ages to its ultimate resistance. Up to an age of one year the bond resistance of specimens stored in damp sand was not affected by as many as four loadings at intervals during the period of storage up to the ultimate resistance. For specimens stored in air and tested in the same way, the bond resistance was less than for damp-sand storage, but the tests showed a steady increase in bond resistance with each loading up to three months. Specimens which had been stored in air for two months before the first test and in water thereafter showed a decrease in bond with each subsequent loading, although the bond resistance in the last test was fairly high. The presence of water apparently permits the continuation of the hydraulic action of the cement for several months after the mixing of the concrete.

(34) Bond resistance of plain bars is greatly increased if the concrete is caused to set under pressure. With a pressure of 100 lbs. per sq. in. on the fresh concrete for five days after molding, the maximum bond resistance was increased 92 per cent. over that of similar bars in concrete which had set without pressure. The greater density of the concrete and its more intimate contact with the bar seems to be responsible for the increased bond resistance. Light pressures gave an appreciable increase in bond resistance. With polished bars the effect of pressure was slight.

(35) As might have been expected, the compressive resistance of concrete setting under pressure was increased in much the same ratio as the bond resistance. At the age of 80 days the initial modulus of elasticity in compression for concrete which set under a pressure of 100 lbs. per sq. in. was about 37 per cent. higher and the compressive strength was increased by about 73 per per cent. over that of concrete which had set without pressure. The density of the concrete, as determined by the unit weights, was increased about 4 per cent. by a pressure of 100 lbs. per sq. in. on the fresh concrete. The increase in strength and density was relatively greater for the low than for the high pressure. A pressure continued for one day, or until the concrete had taken its final set and hardening had begun, seems to have produced the same effect in increasing the strength and elastic properties of the concrete as when the pressure was continued for a much longer period.

(36) Concrete cylinders tested in compression at age of 80 days after having been loaded to failure at 7 days gave compressive strengths nearly as high as those tested for the first time at the same age. Retests of cylinders which had set under pressure gave similar results.

(37) Beams of comparatively short span reinforced with bars of large size were used in order to develop high bond stresses and give bond failures. Most of the beams failed in bond; a few failed by a combination of bond and diagonal tension or by tension in the steel.

(38) The usual method of computing the bond stress in a reinforced concrete beam does not take account of all the phenomena of bond action. Slip of bar due to beam bond action and the presence of anti-stretch slip may be expected to greatly modify the distribution of bond stress over the length of the bar, and otherwise to affect resistance to beam bond stresses. However, the

nominal values for bond resistance, computed by the usual formula, form a useful basis for comparison in beams in which the dimensions and general make-up are similar.

(39) Slip of bar was a phenomena in all beam tests in which careful slip observations were made. These load-slip relations give important indications as to the bond stress developed at points along the length of the beam.

(40) Slip was first observed in the middle region of the span at loads producing a tensile stress in the steel of about 6,000 lbs. per sq. in. In this region the shear is zero, and hence beam bond action, as usually understood, is absent. As the load was increased, slip of bar progressed through the outer thirds toward the ends of the beam at a rate nearly proportional to the increase of load. After slip occurred at the ends, the outer thirds of the length of the bar moved toward the middle of the span relative to the adjacent concrete. Slip of bar was probably partly responsible for the opening of outer cracks, since slipping was observed in the outer thirds of the beams before the cracks became visible.

of the bar, was about 75 per cent. of that for similar beams reinforced with plain round bars of similar size.

(44) Beams reinforced with twisted square bars gave values at small slips about 85 per cent. of those found for plain rounds. At the maximum load, the bond-unit stress with the twisted bars was 90 per cent. of that with plain round bars of similar size.

(45) In the beams reinforced with 1⅛-in. corrugated rounds, slip of the end of the bar was observed at about the same bond stress as in the plain bars of comparable size. At an end slip of 0.001 in., the corrugated bars gave a bond resistance about 6 per cent. higher and at the maximum load, about 30 per cent. higher than the plain rounds.

(46) The beams in which the longitudinal reinforcement consisted of three or four bars smaller than those used in most of the tests gave bond stresses which, according to the usual method of computation, were about 70 per cent. of the stresses obtained in the beams reinforced with a single bar of large size. The progressive opening of cracks with increase in load was well shown in these tests. These beams showed cracks nearer the ends than usual. The distances of the outermost

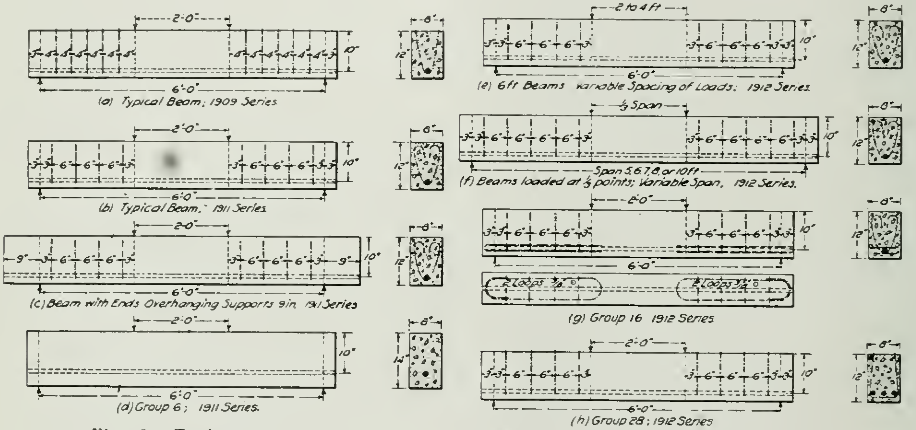


Fig. 2.—Typical Forms of Reinforced Concrete Beams Used in the Tests.

(41) The mean computed values for bond stresses in the 6-ft. beams in the series of 1911 and 1912 were as given below. All beams were of 1:2:4 concrete, tested at 2 to 8 months by loads applied at the one-third points of the span. Stresses are given in pounds per square inch.

	Number of tests.	First end slip of bar.	End slip of 0.001 in.	Max. bond stress.
1 and 1¼-in. plain round	28	245	340	375
¾-in. plain round	3	186	242	274
⅝-in. plain round	3	172	235	255
1-in. plain square	6	190	248	278
1-in. twisted square	3	222	289	337
1⅛-in. corrugated round..	9	251	360	488

(42) In the beams reinforced with plain bars end slip begins at 67 per cent. of the maximum bond resistance; for the corrugated rounds this ratio is 51 per cent., and for the twisted squares, 66 per cent.

(43) The bond unit resistance in beams reinforced with plain square bars, computed on the superficial area

cracks from the ends of the beams suggest that the unbroken length of embedment has an important bearing on the maximum loads which the beams may be expected to carry before failing by bond. It seems probable that the lower computed bond stresses in these tests are due to errors in the assumptions made as to the distribution of bond stress and not to actual differences of bond resistance in the bars of different size.

(47) The tests on beams with the loads placed in different positions with respect to the span gave little variation in bond resistance during the early stages of the tests. The maximum bond resistances increased rapidly as the load approached the supports. These tests indicate that the variation in the maximum bond stresses must be due to the presence of other than normal beam action.

(48) Nearly all the beams tested on span lengths of 7 to 10 ft. failed by tension in the steel and did not develop the maximum bond resistance, although high bond stresses were obtained. The bond stress corresponding to first end slip of bar did not vary much with the span length.

(49) The bond stresses developed in the beam tests indicate that with beams of the same cross-section the bond stresses are distributed in the same way during the early stages of the test in beams varying widely in span length and loading. During the later stages of the test, the distribution of bond stress seems to depend largely upon the conditions of stress in the concrete through the region of the span where beam bond stresses are high. The distribution of bond stresses in beams of different cross section apparently varies with the relative dimensions of the beam and the reinforcing bars.

(50) The use of auxiliary tensile reinforcement in the outer thirds of the beam served to modify the distribution of bond stress during the early stages of the test, but did not have any influence on the maximum bond resistance. While the auxiliary bars seemed to prevent the opening of outer cracks, the tests indicate that interior cracks which did not appear on the surface of the beam may have opened to an extent that permitted the same distribution of bond stress as was found in other tests.

(51) Increasing the thickness of the concrete below the reinforcing bars beyond the depth usually employed caused a very large increase in the resistance to bond and web stresses. The added stiffness of the beam and the increased flexural strength through the outer thirds of the span, prevented the formation of cracks in these regions. In the other beam tests such cracks were found to interrupt the continuity of bond action and to be an important factor in producing lower average bond resistances.

(52) Increasing the length of overhang of the ends of the beam beyond the support did not increase the resistance to web stresses as indicated by the opening of outer cracks, but it had an influence on the bond resistance. The bond resistance at first end slip was greater in the beams with the longer overhang. The maximum bond resistance was materially increased by the additional overhang.

(53) In the reinforced concrete beams it was found that very small amounts of slip at the ends of the bar represented critical conditions of bond stress. For beams failing in bond the load at an end slip of 0.001 in. was 89 per cent. to 94 per cent. of the maximum load found in beams reinforced with plain bars, and 79 per cent. of the maximum load for similar beams reinforced with corrugated bars. As soon as slip of bar became general, other conditions were introduced which soon caused the failure of the beam.

(54) The bond stresses developed in a reinforced concrete beam by a load applied as in these tests varies widely over the region in which beam bond stresses are present. High bond stresses are developed just outside the load points at comparatively low loads. The load which first developed a bond stress nearly equal to the maximum bond resistance in the region of beam bond stresses produced a stress near the support which was not more than about 15 to 40 per cent. of the maximum bond resistance. As the load is increased, the region of high bond stress is thrown nearer and nearer the support, and at the same time the bond stress over the region just outside the load point becomes steadily smaller. This indicates a piecemeal development of the maximum bond stress as the load is increased. The actual bond stresses in certain tests varied from less than one-half to more than twice the average bond resistance computed in the usual manner.

(55) Slip of bar in a reinforced concrete beam has a marked influence in increasing the centre deflection during the later stages of loading.

(56) The comparison of the bond stresses developed in beams and in pull-out specimens from the same materials is of interest. Such a comparison should be made for similar amounts of slip. In the pull-out tests the maximum bond resistance came at a slip of about 0.01 in. for plain bars. The mean bond resistance for the deformed bars tested was not materially different from that of the plain bars until a slip of about 0.01 in. was developed; with a continuation of slip the projections came into action and with much larger slip high bond stresses were developed. The beam tests showed that about 79 to 94 per cent. of the maximum bond resistance was being developed when the bar had slipped 0.001 in. at the free end; hence the bond stress developed at an end slip of 0.001 in. was used as a basis of the principal comparisons in the pull-out tests. However, it is recognized that, under certain conditions, the stresses developed at larger amounts of slip may have an important bearing on the effective bond resistance of the bar.

(57) The pull-out tests and beam tests gave nearly identical bond stresses for similar amounts of slip in many groups of tests, but it seems that this was the result of a certain accidental combination of dimensions in the two forms of specimens and did not indicate that the computed stresses in the beams were the correct stresses. However, it is believed that a properly designed pull-out test does give the correct value of bond resistance, and gives values which probably closely represent the bond stresses which actually exist in a beam or other member as slipping is produced from point to point along the bar. The relative position of the bar during molding may be expected to influence the values of bond resistance found in the tests.

(58) A properly made pull-out test on a specimen of correct design is a valuable aid in determining the bond resistance of reinforcing steel in concrete, if due consideration is given to the load-slip relation. The tensile stress in the bar should be kept well below the elastic limit. Best results will be obtained by using a relatively short embedment. An embedment of 8 diameters is recommended.

(59) A working bond stress equal to 4 per cent. of the compressive strength of the concrete tested in the form of 8 by 16-in. cylinders at the age of 28 days (equivalent to 80 lbs. per sq. in. in concrete having a compressive strength of 2,000 lbs. per sq. in.) is as high a stress as should be used. This stress is equivalent to about one-third that causing first slip of bar and one-fifth of the maximum bond resistance of plain round bars as determined from pull-out tests. The use of deformed bars of proper design may be expected to guard against local deficiencies in bond resistance due to poor workmanship, and their presence may properly be considered as an additional safeguard against ultimate failure by bond. However, it does not seem wise to place the working bond stress for deformed bars higher than that used for plain bars.

It is expected that Lord Kitchener, British Consul-General, will bring to England details of the plans for the barrage on the White Nile, about 37½ miles above Khartum, which are now being prepared by the Egyptian authorities. This great work is to form a necessary auxiliary to the Assiut barrage and the Esnch barrage, the present successful drainage schemes of Northern Egypt. It is expected that within 2 or 3 years, the area in the delta will have been reclaimed; and then the new barrage will be needed urgently. Commencement on the work will probably be postponed for another year, since the receipts from revenue will be low this year in Egypt; and the scheme is estimated to cost about $4,000,000,000.

TENDENCIES IN TRACK CONSTRUCTION.

At a joint meeting in Boston of the American Society of Mechanical Engineers, the Boston Society of Civil Engineers and the American Institute of Electrical Engineers, papers on present tendencies in railroad work were read and discussed. One of these, presented by A. B. Corthell, Chief Engineer, Boston and Maine R.R., had to do with track construction, and reviewed its development during the past half century or more. The Journal for July of the first-mentioned Society publishes an abstract of Mr. Corthell's paper, to which we are indebted for the following:—

The first steel rails made in America were rolled at Danville, Pa., in 1845. Other rollings were made in the same year by the Boston Iron Works, the Trenton Iron Works, the New England Iron Co. and the Phœnix Iron Co. The first Bessemer rail made in the United States was rolled in Chicago in May, 1865; the first Bessemer steel rails to be produced on a commercial order were rolled in Jamestown, in August, 1867. The introduction of the Bessemer process thoroughly revolutionized the art of rail manufacturing, and the ultimate effect on railway building and commercial development of our country can hardly be over-estimated.

Attempts were made about 1870 to roll a combination rail with steel head and iron web and base, but the rapid reduction in price of all-steel rails rendered this process of no economic value, for while steel rails in 1872 sold for $140 per ton, in 1882 the price had dropped to $35 per ton. This cheaper production made possible the heavier rail of recent years, also the larger locomotives, greater capacity cars, and correspondingly greater economy in railroad operations. It is interesting to note in this connection that there seems to have been a fixed relation between the weight of rail in pounds per yard and the weight of locomotives in tons, for when we had 60-lb. rails in general use, we had 60-ton locomotives, and with the 100-lb. rail came 100-ton locomotives; roughly speaking, in 70 years the weight of rails has increased 70 lb., or 1 pound per year.

Not many years ago the designing of rail sections had become a fad. Most engineers were called upon to get up a new standard design, and nearly all roads had their own standard sections. As a matter of record, the rail mills at one time had no less than 188 different patterns and 119 patterns of 37 different weights per yard. The situation was investigated by the American Society of Civil Engineers, and in 1893, after more than three years' deliberation, the Society reported upon standard sections for rail from 40 to 100 pounds, varying in weight in 5-lb. increments. This report was accepted by the Society and recommended to the railroads for adoption during the year 1901. Rails of the above type of sections constituted fully 75 per cent. of all the rails rolled in American mills.

In 1901 the report of the American Railway Association recommending the use of 33-ft. rails was adopted. In October, 1907, a preliminary report was submitted accompanied by two series of proposed standard rail sections, and in 1908 the report recommended types A and B. Since October, 1907, several mills have rolled rails substantially in accord with the new sections, both A and B, and it has been demonstrated that these sections can be finished in the mill at a lower temperature than the A.S.C.E. sections. A finer-grained and better-wearing rail should be secured. However, great care must be exercised in the mills to see that the rails are actually rolled at the lower temperature.

During the year 1913 there has been laid on the Boston and Maine Railroad 500 tons of 85-lb. frictionless rails in curves of 5½ deg. and over, with which it is hoped to lessen materially the flange wear on high rails, which on sharp curves is always considerable. Actual experiment shows that curve resistance is a great deal lessened by the use of this rail. The theory offered for the action of the so-called frictionless rail is based on the means that it offers the outer wheel on each axle to become dominant over the inner one, and the inner wheel to slide laterally to release the outer wheel flanges as they are forced against the outer rail. The outer wheel is traversing a greater distance through a curve than the inner one, but is making the same number of revolutions. On this account, a compensating slide of the outer wheel or a spin of the inner one must occur. The frictionless rail allows this necessary spin to occur at the inside rail.

No subject concerned with track appliances has been more discussed than that of the joint fastening. The evolution of joint fastenings has advanced through three stages: first, the chair which maintains the ends of the rail in alignment and serves as a bearing; second, the fish-plate, which afforded the rail some support under the head, but greatly improved the matter by stiffening the junction of the rails vertically; and third, the angle-bar, which combines the features of the fish-plate and flange, and effected a great improvement in both the vertical and horizontal stiffness of joint fastening; the plain angle-bar is very simple, easily applied and cheap in first cost.

The conditions, which bear some relation to the wear of splice-bars, are the extent of bearing surface and the hardness of the metal. In the new 85-lb. rails and smaller sizes, the question arises whether the plain angle-bar meets with the ideal requirements of the splice-bar in the two important respects, strength, and the wear in the immediate vicinity of the joint, which affects the close union of the parts. We know that angle-bars are not strong enough because they bend and take a permanent set in service, and occasionally one breaks. The supported joints which we have had in use are the Fisher, the Continuous and the Weber joints.

For bolts to fasten the joints to the rails, the most efficient are those having the so-called grip thread. This bolt is made of a soft steel, and the threads are cold-pressed in a manner to upset the metal so as to reduce the diameter of the bolt but slightly at the bottom of the thread. The threads are ratchet shape and under-cut 5 deg. on the bearing side. In the nut the bearing side of the thread is at right angles to the axis of the aperture, so that when it is screwed tight against the splice-bar the threads of the bolt give to the extent of which they are under-cut and the metal will be pushed completely to the outer recesses of the nut-threads, so as to hold the nut against turning off. The nut is square, with the corners chamfered next to the wearing surface, which gives an approximately circular bearing. On the bearing side the nut is recessed the depth of a thread and to a diameter somewhat larger than that of the threaded bolt, thus housing and protecting the many threads against injury by the chafing on the splice-bar.

The first tie-plates were used to prevent rails from cutting into and destroying the ties. Gradual development has added other features, such as the top shoulder, spike-hole, bottom claws and ribs, all tending to make the tie-plate not only a tie protection, but a more valuable rail-brace. Economy of material compels a minimum of weight consistent with strength, and one of the most important considerations is to obtain a tie-plate which will unite firmly with the tie; otherwise it will pound the tie and wear it under rail vibration and afford no lateral resistance to the spreading of the rails. As

such a requirement cannot be had by a plate with a smooth underside, practically all tie-plates are now made with under projections in the shape of claws, which enter the wood crosswise of the grain, or of the flanged or rib type, which enter the wood longitudinally with the grain. In the former case the lateral displacement of the plate is resisted by an abutment against an end section of the fibres. The standard Boston and Maine tie-plate has four flanges which enter the grain of the tie longitudinally, running the width of the plate. The latest tie-plate shows the two longitudinal flanges and two smaller transverse flanges on the bottom, a heavier shoulder and a better portioning of material.

Wooden ties have been almost universally used by the railroads of this country, and are still used as best practice. Steel ties and ties of concrete construction have been made, and are used to some extent with varying success. For wooden ties, the hardwood tie of oak, chestnut and hard pine are used mostly for main line traffic, and the softer woods, such as cedar, for branch lines of light service. The standard Boston and Maine tie is 6 in. thick by 8 in. wide and 8 ft. long. The average life of a chestnut tie is seven ears, and hard pine ties eleven years. The life of a tie can be lengthened by the use of tie-plates and preservatives.

There is indication of no radical change in the present track materials or methods in the immediate future. The rail may be heavier and more spikes, tie-plates and braces added, but the general design will be the same. The changes in turnouts and yards will be most marked; longer switch leads, wider spacings of track, heavier rail and more careful maintenance are already necessary in a great number of our yards, due to the increased loads in power and rolling stock. In the Pennsylvania Terminal in New York City we find part of the tracks laid on stone ballast and some part on a solid concrete base, with creosoted ties bedded therein and anchored by bolts to the concrete.

CONSTRUCTIONAL ACTIVITY IN MONTREAL.

The iron and steel trade in Montreal is greatly interested in the various reports given out from time to time by the big producing firms of the country. The statement of the Nova Scotia Steel and Coal Company for June was regarded as quite encouraging, compared either with a year ago or with the previous month. The figures are as follows, outputs being given in tons:—

	June, 1913.	May, 1914.	June, 1914.
Ore mined	47,200	38,903	44,000
Ore shipped	......	70,129	60,000
Coal mined	67,088	69,349	71,600
Coal shipped	......	61,677	90,000
Pig iron	7,220	......	7,000
Steel ingots	7,147	6,668	10,600
Ingots rolled	......	......	3,770

From the above figures it would seem that the company maintained its output in a satisfactory manner. The activity was evidently greater in June than in May, and the statement is made that the output of steel ingots reached a new high record. This result is somewhat surprising when it is remembered that it was generally considered that outputs of steel companies were very low in June. The trade is looking forward to other companies' reports.

It has developed during the past week or so that orders for structural steel have been running light and it is stated that the principal bridge companies are laying off draughtsmen and other employees. On the other hand, it is asserted that the cement companies are more actively employed, and that they are doing a better business than a year ago. The same is asserted for the brick factories, while other lines of industry send in somewhat similar reports.

INITIAL STRESSES IN STRUCTURAL STEEL.

THE importance of investigation into the subject of initial stresses in steel for structural purposes has assumed a prominence in recent years that is well justified when one is led to observe the low elastic limits, evidently due to initial stress, which tests made on rolled steel shapes have disclosed. Engineers who have noted fractures in fabricated steel work that are indicative of disproportioned stresses and strains are generally inclined to lay the blame upon internal initial stresses. The subject has been well treated by Mr. J. R. Worcester before the Boston Society of Civil Engineers, and from his paper we reproduce the following interesting discussion:—

For many years it has been recognized that where steel is heated locally by forging, there is likely to be produced a region between the heated and unheated portion where the metal is brittle and can be broken by a blow or shock. A striking example of this defect came under the writer's observation recently in the case of some 2-in. diameter steel truss-rods which had been upset. One of these, in unloading from a wagon, had its upset end broken off with a granular fracture. On testing the other rods, by striking the ends with a sledge, it was found that several broke in the same manner, while the remainder could not be broken. A chemical analysis of the fractured ends gave the following result, which is consistent with good metal: carbon, 0.408 per cent.; sulphur, 0.045 per cent.; phosphorous, 0.065 per cent.; and manganese, 0.38 per cent. Although not so certainly established as in other cases, it is quite probable that this fracture was induced by internal stresses caused by the local heating.

A similar defect in I-bars was noticed, soon after the introduction of steel into their manufacture, and led to the universal adoption of annealing furnaces long enough to anneal the whole bar at one time after forging. This practice has recently been proved by Mr. A. H. Emery to be of no benefit, as far as can be determined by tensile tests, as it decreases both the elastic limit and the ultimate strength, while no decrease in strength appears to follow from the local heat treatment, under direct tension as applied in the testing machine. It does not necessarily follow, however, that the annealing may not be a desirable precaution as a safeguard against shock.

Admitting, then, the prevalence of initial stresses, it is interesting to consider their origin with a view to guarding against them where possible. When their origin is in some form of heat treatment it is generally possible to overcome them by annealing, although this may not be the only or the best method. When they are confined to members used in direct tension they may not be of serious import, because, on the application of stress to the member, the effect is to increase the initial tensile stresses already existing, reducing or neutralizing internal compressive stresses. As the applied load increases, a point is soon reached where the fibres carrying most of the tension reach the elastic limit and begin to stretch, after which a redistribution of stress occurs, spreading the stress equally over all the fibres.

A familiar example of this is in the case of a copper wire which may be coiled or crooked with internal stresses. We all know how, if such a wire is stretched beyond the elastic limit all crooks immediately disappear. So with a steel member, if in tension it is in stable equilibrium, and a minute stretch can usually occur without harm to the structure.

With compression members, however, the case is radically different. In these, the first applied load, if con-

flicting initial stresses exist, tends to throw the whole member out of alignment. It is in unstable equilibrium, and the more it bows the greater the danger.

One of the causes of initial stresses is cold straightening of metal before assembling. Cold straightening is, in reality, cold bending, and the following investigation is an attempt to determine the limits of internal stress which may be produced by cold bending.

It is well known that material as it comes from the hot bed is almost always more or less out of line, and that in order to straighten it the most effective and simple method, and the one generally used, is to bend the member, in the direction opposite to the initial curvature, enough so that when it springs back under its elasticity its alignment will be true. The effect of this bending beyond the straight line and allowing the elasticity to bring it back to the correct point is to strain the outer fibres on each side beyond the elastic limit. The elastic recovery reverses the stress in the extreme fibres which have been overstrained, and leaves a condition of stress within the section similar to that shown in Fig. 1.

This means that starting from one edge of the section we find at first a tensile fibre stress extending a certain distance in constantly decreasing intensity until it reaches a point of zero stress, or a secondary neutral axis, beyond which the stress becomes compressive, increasing to a maximum at a point, the distance of which from the outer fibre is the same as that which limited

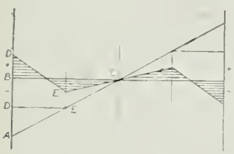


Fig. 1.

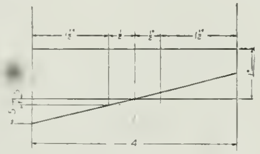


Fig. 2.

the field of metal stressed above the elastic limit by the bending. From this point the compressive stress diminishes to the axis of the section, beyond which it becomes tensile again, increasing to a certain point from which it again decreases, changing to compression at another secondary neutral axis and increasing in compressive stress until the opposite extreme fibre is reached.

By considering Fig. 1 we see at once that with a symmetrical rectangular section we have two fields of tensile stresses and two fields of compressive stresses represented by triangles, and we find that certain assumption may be made with regard to these fields which serve to fix their amounts. In the first place, considering the effect of the bending, if the material was not strained beyond the elastic limit, the stresses on each side of the neutral axis would have been represented by a single triangle ABC. If, however, the stress AB is greater than the elastic limit of the metal, this triangle would be truncated by a line DE parallel to the cross-section and distant from it an amount represented by the elastic limit of the material. When the bending stress is relieved, the line DEC assumes a new position $D'E'C$, the distance from D to D' and from E to E' being proportional to the distance from the neutral axis. This proportionality is one of the determining elements. Another is the fact that the total tensile stress multiplied by the distance of its centre of gravity from the neutral axis must equal the compressive stress multiplied by its axial distance. This is a necessary condition of equilibrium.

Lest it be argued that the line DEC does not agree with the stress-strain diagram, it should be borne in mind that in considering the elastic distortion we are dealing with an extremely minute deformation. Between adjacent planes of cross-section it is really infinitesimal, and any finite stretch would be so small as to produce practically no increment in stress. This consideration is valueless on account of its imaginary character. We might, therefore, without invalidating the argument, assume that we are considering the angle between two planes of cross-section separated by a finite distance, as, for instance, 1 in.

Suppose, for example, a bar 4 x 1 in. bent edgewise, to a radius of curvature such that one-quarter of its width along the neutral axis is still elastic and the remainder, on each side, is overstrained. Referring to Fig. 2, the stretch S, at the limit of the elastic portion,

will be about $\frac{30{,}000}{30{,}000{,}000} = 0.001$ in. The stretch of the extreme fibre S' will be

$$0.001 \times \frac{1.5}{0.5} = 0.003 \text{ in.}$$

The assumption is that the elongation of $S' - S$ will not cause an appreciable increase in stress after the metal has reached the elastic limit, i.e.,

$$S' - S = 0.003 - 0.001 = 0.002 = 0.2 \text{ per cent.}$$

If the gain in strength between the elastic limit and the ultimate strength is accompanied, as it frequently is, by a stretch of 30 per cent., and we assume that the rate is proportional, this stretch of 0.02 per cent. would mean an increase of stress of about

$$\frac{0.02}{30.0} \times 30{,}000 = 200 \text{ lbs.}$$

But, the characteristic of stress-strain diagrams is that there is a sudden yielding accompanied by a very considerable stretch, with no increase in stress; in fact, there may be a slight decrease in stress. It is evident that, in assuming any sharp angle in the diagram, there is a slight error, as the corner should be rounded. It would be more exact to say that the lines assumed are tangent to the curves, but the effect of this rounding may be disregarded without invalidating the theory. Referring to Fig. 3, the above assumptions may be expressed algebraically as follows:—

$$x_1 + x_2 = a \quad \ldots \quad (1)$$

$$\frac{x_1}{y} = \frac{x_2}{z} \quad \ldots \quad (2)$$

$$y + e = u + e - w \quad \ldots \quad (3)$$

$$\frac{v + e}{e} = \frac{a + b}{b} \quad \ldots \quad (4)$$

$$\frac{w}{z} = \frac{a + b}{b} \quad \ldots \quad (5)$$

$$y\frac{x_1}{2}\left(a + b - \frac{x_1}{3}\right) = (b + x_2)\frac{z}{2}\left(\frac{b + x_2 + b}{2}\right)\frac{2}{3} \quad \ldots \quad (6)$$

Solving these equations, we obtain these values for y and z in terms of a, b and e:—

$$y = \frac{2\,(a + b)^2}{a\,(a + 2b)}\,e\,; \quad z = \frac{2\,(a + b)^3}{a^2\,(2a + 3b)}\,e.$$

Letting $a + b = 1$, we find that the equation for y, assuming a as a variable, is a parabola with its vertex at the neutral axis of the section with a value of $\frac{1}{2}e$, the parabola passing through the origin (see Fig. 4). This equation is

$$y = \left(a - \frac{a^2}{2}\right)e, \text{ or } 2a - a^2 = \frac{2y}{e}.$$

Expressing this result in words, it amounts to this: If a rectangular bar is bent so that it has any permanent set, the internal maximum fibre stress may be obtained if we know to how great a depth the outside portion of the section has been stressed beyond the elastic limit. The amount of this internal stress can never exceed one-half the elastic limit, and between o and $\frac{1}{2}e$ it varies according to the abscissas of a parabola of which the axis is the neutral axis of the section.

We may determine the depth to which fibres are stressed beyond the elastic limit if we know the radius of curvature and the thickness or depth of the section.

We know from mechanics that $\frac{1}{r} = \frac{e}{Ed}$, in which r is the radius of curvature, e is the elastic limit of the material, E is the modulus of elasticity, and d, the distance

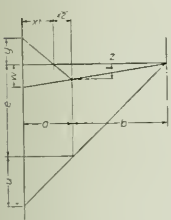


Fig. 3.

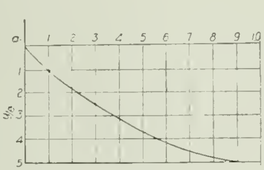


Fig. 4.

from the neutral axis to the extreme fibre. Using 30,000 for e and 30,000,000 for E, this formula becomes, $r = 1{,}000\,d$. In other words, the distance from the neutral axis to the fibre which is strained just to the elastic limit will be 1/1,000 of the radius of curvature; hence, if we know approximately the radius of curvature, we can tell at once what part of the thickness of the section is not overstressed, and, subtracting this from one-half the total thickness, we can find a. Taking a practical example of this, we should obtain the following results:—

Assume a bar 3 x 1 in. to be somewhat crooked edgeways and to be straightened in a press. Let us assume that in straightening it is curved to a radius of 12 ft., a very moderate assumption.

The width of metal not overstressed would be

$$\frac{12 \times 12}{1{,}000} = 0.144 \text{ in. each side of the neutral axis.}$$

a would, therefore, $= 1.5 - 0.144 = 1.356$ in.
or, on the basis of $a + b = 1$, $a = \frac{1.356 \times 1}{1.5} = 0.9$.

From the diagram, Fig. 4, we find that under these conditions, y, the initial fibre stress amounts to $0.495\,e$, tension on one edge and compression on the other, or approximately 15,000 pds. per sq. in. This means that in a bar which is quite straight and wholly "innocent" in appearance there may exist a compressive stress along one edge of 15,000 lbs. per square inch, while along the opposite edge is a tensile fibre stress of an equal amount; in other words, an inherent tendency to bend out of line on the least "provocation." This condition cannot be detected by any of the usual methods of inspection, but might be suspected if we knew its history.

It will be noted that the above analysis applies only to a rectangular section. In the case of an irregular section, such as an I-beam, it is evident that if the bending is in the plane of the web, a lesser stress in the extreme fibre will produce equilibrium on account of the decreased area of the section in the parts nearer the neutral axis. On the other hand, if the bending is at right angles to the web, the converse is true, and the extreme fibre stress will be greater proportionally, and may easily approach nearer to the elastic limit. The same is true of a bar with a circular cross-section.

Let us now consider the practical effect of these internal stresses. Referring again to Fig. 1, we see that if we apply an axial stress to a member which is already subjected to this condition of internal stress the effect will be to produce a condition as shown by Fig. 5. In this case we see at once that the areas of stress will be unbalanced, so far as the rotating moment is concerned.

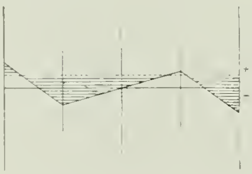


Fig. 5.

The effect of this unbalanced condition will be to produce a tendency to spring out of line. If the axial stress is in tension, this tendency is offset by the axial stress itself, and even in case the extreme fibre stress exceeds the elastic limit, a slight yielding of these fibres soon distributes the stress more uniformly, and so no serious results can occur. But if the axial stress is compressive, the tendency to spring is very serious and immediately throws the strut out of equilibrium, so that the bad effect of the internal fibre stress is accentuated. If the elastic limit is passed, the buckling may even continue to the point of failure.

Mr. Worcester did not enlarge upon applications of the above theoretical considerations. His paper, nevertheless, shows the tremendous importance of eliminating cold straightening so far as possible from the shop treatment of metal which goes into compression members.

On June 19, Kingston dock, Glasgow, Scotland, was completely destroyed by fire, entailing damage to the extent of \$1,250,000. The original cost of the dock was \$750,000; but extensive alterations and improvements have been in progress during the past year. The collapse of the quays carried with them huge cranes, thousands of feet of iron girders, and rooms of sheds. In addition four schooners, laden with seal oil and other products, were destroyed.

According to M. Hans, Dempwolff, of the staff of the Prussian Government Railway, and a recent visitor to Canada, a large scheme is now being considered in Berlin for electrifying the suburban and interurban railway systems, which are run on elevated tracks as in a number of the leading American cities. The cost of the work would involve the expenditure of something like 150,000,000 marks (\$30,000,000.) The German Government, he remarked, was experimenting with electric locomotives, and was trying out Deisel engines on its lines.

WHARNCLIFFE HIGHWAY BRIDGE, LONDON, ONT.

By F. M. Brickenden.

THE city of London, Ont., with its population of 48,000 is situated on the River Thomas. The location with respect to the main river, and particularly its north and south branches, is such as to require a considerable number of highway bridges to convey the traffic from one part of the city to another. A new bridge, to be called the Wharncliffe highway bridge, is at present under construction. It is the first to cross the main river, and is one the need of which has been felt for a number of years, particularly since the annexations of London South and London West, both of which were until a comparatively short time ago municipalities outside the city. The site is shown in Fig. 1. It is about ¼ of a mile downstream from the forks of the north and south branches of the Thames.

Before its municipal development London West was a low-lying piece of land, and has had to be protected on the river side by a breakwater. London South, however, in the vicinity of the bridge site, is on an elevated strip of land. Further, owing to the directions of the currents produced by the junction of the two branches of the river, and taking into consideration the ice brought down in the spring, assisted by the fact that the two centre lines of the Wharncliffe roads in London South and London West do not coincide, it was found necessary to design the bridge on a skew. The angle of the substructure was accordingly set out at 113° 29′.

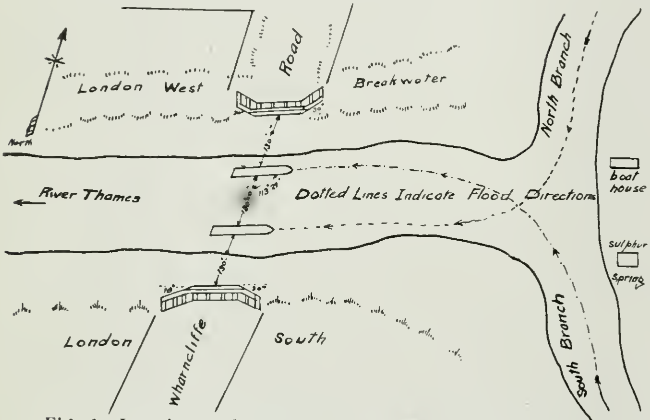


Fig. 1—Location and Layout of the Wharncliffe Highway Bridge, London, Ont.

Excavation.—Underlying the bridge site is what is known locally as London South white clay. This clay is used is another locality for the purpose of making white brick. It is of such a nature as to puddle readily upon mixing with water. Because of this considerable difficulty was experienced in excavating for the south abutment of the new bridge. Clay slid into the excavation on several occasions. The work was started in August last, and the contractors adopted the pick-and-shovel method of removing the clay to a depth of approximately 20 ft. For a part of the time a team and slush scraper were employed. As the clay developed drying cracks on exposure, blasting with black powder was found ineffective when tried.

When the excavation had attained a depth of about 10 ft. a 10-in. cast-iron water main was encountered, necessitating, of course, its removal and relocation to one side of the bridge site. The pipe was found to lie directly under the entire length of the proposed bridge. As the river reaches a depth of about 3½ feet, at low water mark, a special arrangement was necessary to place this 300 feet of water main on the bottom without breaking the caulking. The entire river length was accordingly placed on the bents, each about 9 ft. high. It was then hung from the threaded rods by a wire. The rods projected through the top of the bents and then held by wrenches. To lower, 28 men were placed, one at each bent, and on a given signal, each gave his wrench one turn, thus lowering the whole as a unit. The excavation of the south pier footing was simply sheet-piled, and on reaching the bottom 30 hardwood piles were driven and cut 9 in. up from the bottom level. For the north pier a wood caisson was built, and between the outer and inner parts the intention was to fill with earth and sink to a firm foundation. This was done, but considerable trouble was experienced because of the pressure of the water on the outside of the cofferdam, forcing through the light filling material used in sinking the framework. This was pumped out by means of a centrifugal pump, driven by an 8 h.p. gasoline engine (a small, power diaphragm pump was used in pumping out the other pier excavation). This foundation, although of very good quality white clay, was filled with 30 piles driven to refusal.

The 30 piles for the south pier were driven by means of a horse-driven capstan, lifting about 1,500 lbs. to the height of 18 ft. This operation took an average of 111 seconds from blow to blow. For driving the remaining 30 piles a small hoisting apparatus was connected up with the 8 h.p. engine by a chain, and from the hoisting-drum a cable was fastened directly to the hammer of the pile-driver, so that after raising the hammer it fell, drawing out the cable and ready to start again. The operation of this method consumed at best but 11 secs. from blow to blow, although much time was wasted, in that the leaders used were unsuitable.

The excavation for the north abutment was through the West London breakwater, about half being taken out by means of team and scraper, and the remainder removed by shovel.

Both the abutments were laid out with the short centre line as the line of the bridge-seat on the coping. This line located, the counterfort walls were at right angles to the face, so that the angle turned assisted in the layout of these forms. The angles of the wings were all turned with the transit. The layout of the south pier was simply by direct means, but, as the north pier was entirely in the water at its lowest, the method used for it was different. A wire was stretched along centre line, with the centre point marked equidistant from pier and abutment. The skew was first set by measuring along a triangle applied to the caisson and scaled off the plan. This was checked by measuring along sides of a parallelogram from shore, and later having a stage placed on the cofferdam when the angles were checked with the instrument.

It may be mentioned that the city of London controls the height of the water in the Thames by their

waterworks dam, four miles down the river; so that the level of the water was reduced 3 ft. during pier construction last fall and this spring.

Reinforcing.—The building of the counterforted abutments gave rise to several noteworthy conditions. For example, when the supporting walls or counterforts were being formed, they were battered up from a base-slab, which was 12 ft. in thickness at the bottom, and 57 ft. or 52 ft., according to the abutment, to the top of the ballast wall. At the points of wings and main wall the counterforts are 2 ft. thick, double the width of the remainder. The inclined reinforcing was hooked at the rear of the base reinforcing and ran up 3 in. from the back of the counterforts to the top. The rods used were of three sizes, ½ in., ¾ in., ⅞ in., all square. The base-slab was reinforced by having rods ¾ in. diam. placed across the whole of it, parallel at right angles to the face. To this all the vertical and inclined rods were hooked, thus making the base serve as an anchorage against overturning. Besides the inclined ⅞-in. rods in the counterforts, 3 pairs of ½-in. rods of different lengths were placed vertically, so that they ran to the inclined rods of the latter, and were hooked to them.

Parallel to the base and running 3 in. from the face, other rods were placed up to the bridge-seat. In front of these and in a vertical position were other ½-in. rods, to which were hooked the small, horizontal rods of the counterforts. In the bridge-seat were a number of short ¾-in. rods, laid parallel to the short diameter, and wired to these were several long ½-in. rods, horizontal and parallel to the face.

The ballast wall was reinforced by having short ¾-in. vertical rods, attached to long ½-in. horizontal rods, along the entire length of the wall.

Piers.—The north foundation forms and cofferdamming were radically different from that of the south, which consisted of a sheet piling only. The portion nearest the shore was shallow and easily kept dry, even when the river rose somewhat above the lowest water level obtainable for the work. A ring of clay around the excavation formed a barrier to the water. The seepage water was, as stated, removed by a power diaphragm pump.

The forms for the pier were of simple construction except the nosing. It had to be specially detailed to suit the cut-waters, which were only rolled as regular right angles rather than specials. The detail showed the nosing running back from the ⅞-in. cut-water angle at right angles to nose-point, or at a tangent to its curvature. The amount of curvature did not change, but the tangent or right angle of the nosing varied for each 2 ft. of rise, leaving the joint between tangent and curve vertical and imperceptible. This nosing then required a special form, built up in shapes roughly represented by the letter "U." These fitted over the cut-water angle, holding the form boards in place. The boards were placed vertically, being strongly wired to the 2 x 6-in. uprights which were outside the U-shaped forms.

Generally, the scantling was placed 18 in. apart and wired every 2 ft. with No. 9 galvanized, medium hardness, wire. All forms were oiled with a heavy oil, acting as a filler. Openings of any size were plugged with hard soap.

The north pier occasioned the placing of two cofferdams, one being heavily timbered, with an outer and inner shell. The caisson principle was tried, and this first floated into position and sunk. It required a great deal of filling, followed by many days of pumping before the excavation could be started in the river bottom.

Owing to the lateness of the season there was much uncertainty about the weather. The floods, carrying ice, washed the whole cofferdam away, filling in the work done during the early winter with river muck and debris. To get this in shape again for concrete a different method was used to get the old excavation cased in again, and watertight. A framework was built of 2 x 6's, covered with tongue-and-grooved lumber, and stiffened by corner-braces. The lower, or downstream end, was left uncovered. The boarding reached a height of 6 ft., this being sufficient for the depth of the low water then in the river. This was floated over the piling, which had survived the onslaught of the ice, and was sunk into place, the open end being sheet-piled. Around the whole cofferdam were placed sand-bags and loose sand. This, with the aid of the centrifugal pump, reduced the water again to a workable depth.

Concrete.—The abutments were concreted first. The base of each was concreted for 6 in. and the base reinforcing placed. Concrete was then poured to the level of the base of the vertical walls and top of base plinth. The upper reinforcing was held in position by a framework.

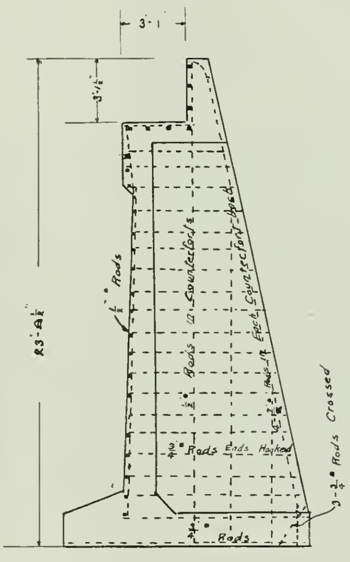


Fig. 2—Section of Counterfort, North Abutment.

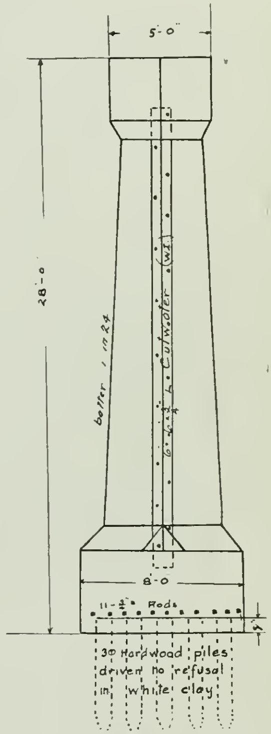


Fig. 3—Typical Pier Section.

After placing the forms the concrete was placed to the coping to allow the bridge-seat reinforcing to go in place, then continued to the base of ballast wall. The long, horizontal rods were then wired to the short uprights, allowing the completion of the remainder.

The placing of concrete for the pier was more difficult. The abutments only required a few lengths of semi-circular troughs, with a bent-end and a small hopper, while the piers required about 150 ft. of troughs, supported on a trestle-work that carried also a plank walk, for workmen.

When the piers rose to about one-third their height, a series of stages were erected at the form end of the chutes, upon which were men who passed up the concrete from one level to another to its position in the pier.

About 700 cu. yds. of concrete were placed, three mixtures being used; bases in water, 1:6 + 25 per cent. cement; ordinary, 1:6; nosing piers, 1:4.

No plaster coat was added to the faces. They were carefully smoothed and a wash applied, making all of the concrete of uniform color.

Steel.—The contractors for substructure and superstructure were both agreeable upon request to leave the drilling for the rag-bolt holes in the seats till a direct bearing-plate on abutment fixed directly off the connection-plate.

The portals are skewed, so that the ends of the end floor beams are sawn at flanges. The angle connections are special to suit 113° 29′ and 66° 31′. The remaining floor beams are placed at right angles to the bottom chord. The stringers are also cut obliquely at the ends of span to fit over the skew beams. The bottom laterals are angles, with legs 2½ x 2½ in., except end panels, which are 4 x 4 in., being rivetted at the centre. The top struts are built of 7-in. channel, edged to web of 6-in. channel, and hung from their connection at the top panel joint. The top laterals are 2½ x 2½ in.

The knee braces attached to the posts and top struts give greater stability from wind stresses which are rather excessive in this valley. The portals are arranged with angles and channels on edge, giving a neat appearance. The sidewalk consists of cantilever brackets having 10-in. I-beam stringer in centre for floor, a channel with angle on upper flange for curb of walk. A latticed railing is on the outside of the walk and inside of the upstream truss.

Erection.—The erection presented a few difficulties, mostly in the placing of the falsework in water—the

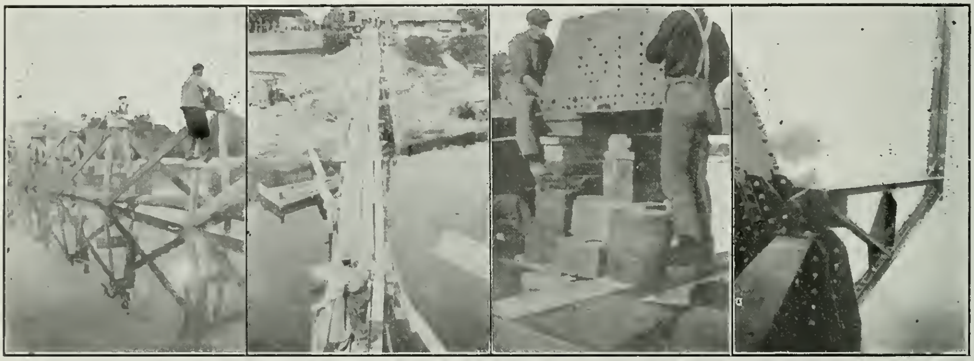


Fig. 4—Views of Bridge Construction—Method of Placing 10-in. C.I. Water Main—Chute for Transporting Concrete to Piers—Rivetting a Bottom Chord Splice—Sidewalk Cantilever Adjustment.

after the steel was erected and centred; the rag-bolts of the cut-water angles were concreted in with the nose. The steel of the bridge consists of three spans, all portals skewed, and the downstream side carrying a cantilever sidewalk (bracketted at each panel joint). The bridge spans are through rivetted trusses. The steel is being erected by what might be called the "Armstrong" method. An idea of the size of the connections and splices may be formed by the fact that the whole structure will require about 7,000 rivets, field-driven. The structure rests on three types of bearings. The south, or expansion end, is of a roller type, resting on a bearing-plate and supporting a slotted plate from the connection of end-post and bottom chord; five rollers to each corner, each roller of 3½ in. diam. The plate is held in position by 2-in. rag-bolts. The bearing-plates all rest on sheet lead, which serves to prevent the action of the free alkali on the steel plates. The bearing casting for the fixed end is a casting over 4½ in. thick. It is partly cast hollow in pockets on the underside, thus reducing the weight, but retaining sufficient strength to resist compression. It rests directly on bearing-plate. The third style used is height which the falsework bents had to rise above the water, compared to the depth of the river, gave no great amount of buoyancy in raising the heavy timberwork. Besides this difficulty, the falsework of the first span, though placed through the ice, had two bents washed out by a flood following the first week of erection, requiring much patience to take lines across the river by means of a rowboat and fasten them there. The erection of the second span being entirely over water, was more noteworthy. The depth of the water was about 7 ft., so that it was not convenient to work a "gin" pole in the river. A built-up "stiff-leg" was placed, projecting over the southerly pier and stayed back to the steel already erected. A bent was built up on shore of 12 x 12 in. material, braced, capped and towed under a hook operated by a pair of "three" blocks swinging from the "stiff-leg." To the end of the loose, threaded line a second pair of "three" blocks was attached and laid out by which the gang of men were able to raise the bent to almost its proper position.

By moving this arrangement to the top of each bent as raised, the eight bents required were speedily placed in their position and braced.

The bottom of the river at this point is gravel over clay, and, as there was no settlement of the falsework, the bents upon being placed were connected longitudinally over the caps by 3 and 4-in. lumber.

In the centre a runway was made by laying down the I-beam upon the centre pair of longitudinal timbers. This double runway was to accommodate the movement of the steel from the storage to its position in the span by means of a cart with a tongue and looped axle arrangement, whereby the steel when attached to the axle could be raised clear of the ground, and by balancing its connection was easily shoved along by a few men. The longest of the heavier top chord sections, 40 ft. in length, was moved this way.

After placing 12-in. I-beams to serve as a runway over the falsework, the bottom chord was next brought into position and rivetted at its splices. This was necessary and expedient at this juncture, because the chord was built up of 2 angles, edge to edge, at end panels, and 4 angles in the middle of the span to take up the greater stresses existing there. This in position, with its vertical connections at the panels, and 2 diagonals, hangers, or end-posts, would have made the splice rivets impossible to drive when all was erected.

Floor System.—The floor system consists of 24-in. I-beams across at all panel joints, about 20 ft. apart, except the ends of the span, or skew beams, which are both 20-in. I's. Because of the oblique angle, 66° 31′, the permanent connection between the lugs and end-post base is made with turned bolts and lock washers. Centered over this beam system, 12-in. I-beams form the stringers, those over the end skew-beams having to be

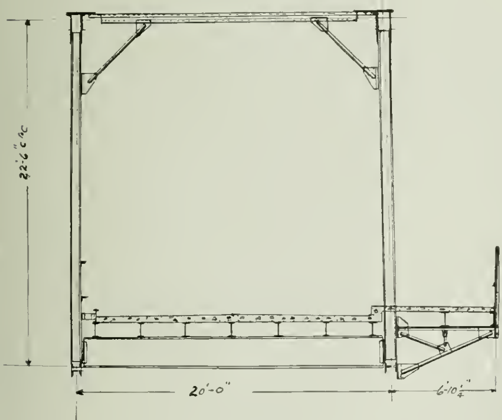


Fig. 5—Section of Bridge at a Centre Panel Joint.

of special length. The stringer opposite to the sidewalk, on the upstream side of span, has a channel on its top flange which forms, with back inwards, the curb of the roadway.

On raising the end-posts, a block and line were attached to the top of the hanger by which the end-post could be hauled into position and bolted at the top to the hanger and to the lower chord at its low end, resting on the bearing-plate of pier. A "traveller" was made of 8 x 19-in. timbers, with upright legs, high enough so that the projecting ends of cap-piece, suspending two sets of blocks, would not come in contact with the top chord or verticals till they were above their position, and could easily be lowered into the position when ready for bolting. The same block method was used as in raising the bents, these pieces were raised by the double three blocks, requiring about 10 men on the line.

Posts or verticals were all placed previous to raising the diagonals. To place them the "traveller" rig had to be shifted by means of pinch-bars, the bottom of both uprights moving along the same thickness of plank. The guy-ropes were held by fastening them around the various

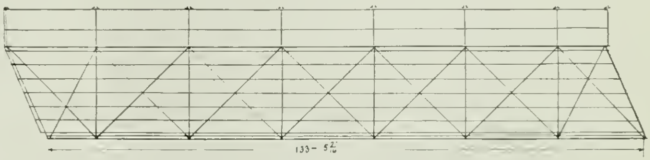


Fig. 6—Floor System.

erected members. In the case of the most distant top chord, these ropes had to be taken across the river and there fastened to a post on the breakwater. This method applied also to the extreme posts of the span.

Laterals and Struts.—Rivetting was done by hand, the outfit consisting of 3 men and a heater. Top and bottom laterals, knee-braces and struts of portals are erected as the rivet gang reaches the connection. The same can be said of the cantilever sidewalk brackets, which were held out by block and line, then set in position by the coupling-up pins and bolted. Only such of these as were needed to resist wind stresses were placed at the time of erection on the falsework.

The floor is to be reinforced concrete roadway of 18 ft. clear width, and the sidewalk 6 ft. The total length of floor is 409 ft. 1 in. This conforms to the Ontario Government specifications for a 15-ton bridge.

The substructure was built by the firm of Bain and Ross. The steel is supplied and erected by the Hamilton Bridge Company. The work is being done under the direction of Mr. W. N. Ashplant, the City Engineer.

Among large buildings at present under construction at Saskatoon, Sask., are a large store and office block, a cold storage warehouse, a distributing warehouse for the Prairie City Oil Company, a business block for the Canadian Townsite Properties, Limited, a new sedimentation basin, and an additional students' residence at the University of Saskatchewan. The interior storage elevator for the Dominion Government also is expected to be completed for this season's harvest. While the new bridge across the Saskatchewan River at Twenty-Fifth Street, being erected at a cost of about $500,000, is to be completed by the fall of 1915.

The Taku Railway and Navigation Company has filed in the land office at Juneau, Alaska, right-of-way and terminal plans for the proposed railway line up the Taku River from a point on Taku Inlet to the Canadian-Alaska boundary. About two miles of side cut rock work on the lower end is encountered. The line for the most part is tangent and free of short or sharp curves. It follows the flat in the valley almost the entire distance and tranverses three tracts of good timber. The grade is said to be considerably less than 1 per cent. The terminal is located on the south side of Taku Inlet just opposite Windom Glacier, which has been dead for some time. The Inlet is narrow at this point and not over 40 feet in depth; and the feasibility of bridging the canal at this point and continuing the line to Juneau has been discussed and is believed by engineers to be practicable. F. J. Wetrick, of Wilhelm and Wetrick, who made the survey for the American line of the railway, is now making a preliminary survey on the Canadian side to Atlin.

SASKATCHEWAN REGULATIONS GOVERNING WATER AND SEWERAGE WORKS.

THE Bureau of Public Health of the Province of Saskatchewan has just issued some important regulations governing the preparation and submission of plans and information with reference to the installation and extension of waterworks, sewerage and sewage disposal systems. These were prepared by Mr. R. H. Murray, A.M.Inst.C.E., engineer to the Bureau, under the direction of Dr. M. M. Seymour. Public Health Commissioner, and form an excellent system of standardization of such proposals, Saskatchewan being the first province of the Dominion to issue regulations of this nature. They were compiled primarily to facilitate the preparation and examination of plans and information pertaining thereto, and supplement the provisions of sections 21, 22 and 23 of the Public Health Act.

Respecting the plans and data required for provisional and final certificates, the following constitute the requirements of the Commissioner for Waterworks systems and extensions: Engineer's report; estimates of cost; general plans; analysis of proposed source of supply, and affidavit covering the same; detail drawings, specifications and affidavits covering both.

For sewerage and sewage disposal systems and extensions the same items apply with the exception of the analysis of proposed source of water supply. In the case of storm sewerage systems and extensions, affidavits will be required to cover general plans, also.

If the information and data submitted with reference to any proposed system or extensions are satisfactory and complete in the first instance, the Commissioner may issue his provisional and final certificates together.

Waterworks Systems and Extensions.—A report shall be submitted prepared by the engineer acting for the municipality giving information under the following heads, in so far as such are applicable to the proposed works:—

Population—The present population and the rate of increase during each of the past five years; available data justifying a future increase of population and probable increase in next ten years.

Maximum population which system will provide for if fully developed.

Population provided for by proposed system.

Area and topography of municipality.

Estimated water consumption per capita per twenty-four hours.

Alternative sources of supply (if any) and if investigated.

Source of supply recommended.

Present available supply of water and how determined.

Estimated supply of water under full development.

Quality of water.

Any present sources of pollution of source of supply.

Measures recommended to prevent future pollution of source of supply.

Nature and construction of intake or collection works.

Wells—The number, depth, size and construction of wells; the nature of the ground through which they are sunk; the construction of collecting galleries.

Watercourses—Minimum dry weather flow, approximate watershed area. If continuous winter flow; reduction in available supply during winter.

Catchment areas—Approximate area of watershed, character of watershed surface with reference to probable run-off, population, arable and stock farming and all available data having reference to rainfall.

Natural lakes—Approximate area of watershed, average depth of lake, area of lake, if overflow is continuous, approximate annual overflow, nature of watershed relative to population, arable and stock farming, and all available data having reference to rainfall. Population on shores winter and summer. If surface is used for traffic in winter.

The capacities and character of pumps; duplication of machinery and energy.

Sedimentation—The size and construction of basins.

Filtration—A full description of the proposed plant including the type of filter, the nature of filtering media, the maximum rate of operation of each unit of the plant; the method of cleansing filtering media; the nature and amount of coagulent or disinfectant estimated to be necessary.

Provision for future extensions.

Provision for measuring and recording amount of water supplied to municipality.

Provision made for storage and capacity of reservoir, stand pipes, etc.

Size of force or gravity mains.

Distribution system, especially with reference to cut-off valves, sluice valves, hydrants and through circulation; minimum size of pipes and minimum depth of trench; character of subsoil.

Pressure available for domestic and fire purposes.

Particulars as to any provision made for turning water other than the domestic supply into mains for fire protection purposes.

Provision to be made for inspection of construction.

Control and operation.

In the case of extensions to an existing system, the report shall, in addition to describing the nature of the proposed extensions, deal with as many of the above matters as are thereby affected.

Estimates of Cost.—A statement prepared by the engineer shall be submitted showing the estimated cost of the proposed system or extensions. The estimated cost of all pipe lines shall be shown in schedule form as follows: (See Schedule A, page 183.)

The estimated cost of all other sections of the work (e.g., land, intake, headworks, pumps, reservoir, hydrants, valves, etc.) shall be shown separately at the end of the schedule. The estimated operating costs per annum shall also be given.

General Plans.—The following plans shall be submitted:—

(*a*) Plan of Municipality.—A general plan of the entire municipality to a scale of not greater than 200 and not less than 500 feet to an inch. This plan shall show:

1. The municipal boundary.
2. All streets existing or proposed.
3. The approximate location of all habitable buildings not served with water at the date of application.
4. The surface elevations at all existing or proposed street intersections.
5. The elevation of the highest point in the municipality.
6. The location and size of all existing and proposed water mains.
7. The location of stand pipes, valves, hydrants and all appurtenances.

(*b*) Location Plan.—A plan to a suitable scale showing the site of the municipality, any outside territory affected, and the following:

1. The source of supply, intakes, wells, filters, pumps, reservoir and any special features.

2. The route of gravity or force mains.

3. The following elevations shall be shown: (*a*) The low, mean and high water levels of the watercourse or lake at the intake. (*b*) The highest known flood elevation of the watercourse or lake. (*c*) Surface and water elevations at standpipes, reservoirs and principal points in the system. (*d*) Surface elevations showing any irregularities of route with reference to the hydraulic gradient.

This plan is not required in the case of extensions to a distribution system.

Analysis of Proposed Source of Supply.—A sample of the water from the proposed source of supply shall be taken not more than six weeks previous to the date on which application is made to the Commissioner of Public Health for his certificate of approval. The sample shall be subjected to chemical analysis and bacteriological examination. A copy of the result of such analysis shall be submitted to the Commissioner of Public Health. The commissioner may require any number of samples extending over a stated period of time, if necessary.

The above shall also apply to each application for approval of extensions to an existing system, the sample being taken from the existing mains, should there be no proposed change in the source of supply.

An affidavit shall accompany any report of water analysis stating that the report of analysis and examination submitted is a true copy of the report supplied by the analyst, and that the water analyzed and examined was taken from the proposed source of supply. The date on which any sample was taken shall also be stated in the affidavit.

Detail Drawings.—Detail drawings shall be submitted to a scale which shall clearly indicate the design of all sections of the proposed system or extensions, including all wells, collecting galleries, intakes, filters, settling basins, reservoirs, conduits, standpipes, siphons, blowoffs, pumps, machinery buildings and other appurtenances.

In the case of a gravity supply, a profile of the route of the pipe line shall be submitted, showing surface elevations, the hydraulic gradient of pipe line, and air and sluice valves.

Specifications.—Specifications shall be submitted covering all work to be undertaken in the proposed system or extensions.

All detail drawings and specifications shall be accompanied by affidavits stating that the drawings and specifications so submitted are those to be used and followed in the construction of the proposed system or extensions.

Sanitary Sewerage Systems and Extensions.—A report shall be submitted, prepared by the engineer acting for the municipality, giving information under the following heads, in so far as such are applicable to the proposed works:—

1. Population—The present population and the rate of increase during each of the past five years. Available data justifying a future increase of population and probable increase in next ten years.

2. Maximum population which system will provide for if fully developed.

3. Population provided for by proposed works.

4. Area and topography of municipality.

5. Water consumption in municipality per capita per 24 hours.

6. The character of the sewage (with reference to surface and roof water, trade wastes, etc.)

7. Estimated maximum rate of flow expressed in gallons per hour.

8. Estimated normal dry weather flow expressed in gallons per 24 hours.

9. The general nature of subsoil throughout the municipality.

10. Precautions to prevent infiltration in water-bearing strata.

11. The minimum grades of all sizes of sewers.

12. Provision made for flushing and the intervals of flushing.

13. Character of pipes and joints to be used.

14. Type of sewage lifts to be adopted.

15. The maximum distance between manholes.

16. Ventilation of system.

17. Storm overflow discharges and any points of discharge other than the sewage disposal plant.

18. The areas of the municipality which cannot drain by gravity into proposed system. The proposed method of providing drainage for such areas in the future.

19. Provision to be made for inspection of construction.

20. Control and operation.

In the case of extensions to an existing system, the report shall, in addition to describing the nature of the proposed extensions, deal with as many of the above matters as are thereby affected.

Estimates of Cost.—A statement, prepared by the engineer, shall be submitted showing the estimated cost of the proposed system or extensions. The estimated cost of all pipe lines shall be shown in schedule form as follows: (See Schedule B, page 183.)

The estimated cost of all other sections of the work (e.g., manholes, inspection chambers, sewage lifts, etc.) shall be shown separately at the end of the schedule. The estimated cost of operation per annum shall also be given.

General Plans.—The following plans shall be submitted:—

(*a*) Plan of Municipality.—A general plan of the entire municipality to a scale of not greater than 200 and not less than 500 feet to an inch, this plan shall show:

1. Municipal boundary.

2. All streets existing or proposed.

3. The approximate location of all habitable buildings not connected with sewers at the date of application.

4. The surface elevations of all existing or proposed street intersections.

5. The location, size and direction of flow of all existing and proposed sewers.

6. The location of all existing and proposed manholes, lampholes, flush tanks, sewage lifts, sewer outlets, overflows and other appurtenances.

7. Any areas from which it is proposed to pump the sewage; these should be indicated by light coloring or shading.

(*b*) Contour Plan.—A contour plan of the municipality to a suitable scale.

Detail Drawings.—Detail drawings shall be submitted to a scale which shall clearly indicate the design of all parts of the proposed system or extensions, including all manholes, lampholes, flushtanks, siphons, pump wells, inspection chambers, buildings, iron work, machinery and other appurtenances. Transverse sections of all sewers over 24 inches in diameter shall be submitted.

Profiles of all sanitary sewers shall be submitted. The following scales are suggested for general adoption:

Vertical 10 feet to an inch
or 20 feet to an inch
Horizontal 80 feet to an inch
or 100 feet to an inch
or 200 feet to an inch

Profiles shall show all manholes, lampholes, flush-tanks, siphons, river and railway crossings, the size and grade of sewers, the elevation of sewer invert and ground surface at all manholes and changes of grade; elevation of river or stream beds crossing the line of sewers.

Specifications shall be submitted covering all work to be undertaken in the proposed system or extensions.

All detail drawings and specifications shall be accompanied by affidavits stating that the drawings and specifications so submitted are those to be used and followed in the construction of the proposed system or extensions.

Storm Sewerage Systems and Extensions.—A report shall be submitted, prepared by the engineer acting for the municipality, giving information under the following heads, in so far as such are applicable to the proposed works:—

1. Precipitation—All available data having reference to the maximum precipitation in the municipality, particularly with reference to short periods of heavy precipitation.
2. Nature of ground surface—The areas paved and unpaved, and in the case of the latter, the degree of porosity of the ground.
3. The area and mean slope of each district draining to a trunk sewer or point of discharge.
4. The data and assumptions upon which the computation of the size of sewers is based.
5. The estimated maximum volume of flow (in cubic feet per second) at each point of discharge, and the estimated increase when the system is fully developed.
6. The character of pipes and joints to be used.
7. The nature of coating (if any) to be used on the outside of pipes.
8. Any connections which it is proposed to make with the sewers, other than for surface water.
9. Provision to be made for inspection of construction.
10. Control and operation.

In the case of extensions to an existing system, the report shall, in addition to describing the nature of the proposed extensions, deal with as many of the above matters as are thereby affected.

Estimates of Cost.—A statement, prepared by the engineer, shall be submitted showing the estimated cost of the proposed system or extensions. The estimated cost of all pipe lines shall be shown in schedule form as follows: (See Schedule C, page 183.)

The estimated cost of all other sections of the work (e.g., manholes, catch basins, etc.) shall be shown separately at the end of the schedule. The estimated cost of operation per annum shall also be given.

General Plans.—A general plan of the entire municipality shall be submitted to a scale of not greater than 200 and not less than 500 feet to an inch; this plan shall show:

1. Municipal boundary.
2. All streets existing or proposed.
3. The surface elevations of all existing and proposed street intersections.
4. The location, size and direction of flow of all existing and proposed storm sewers.
5. The location of all existing and proposed manholes, catch basins and connections to the storm sewerage system, also all points of discharge and natural watercourses.
6. The extent of street paving.
7. The areas draining to each trunk sewer or point of discharge (these may be shown by distinctive coloring or shading).

Detail Drawings.—Detail drawings shall be submitted to a scale which shall clearly indicate the design of all parts of the proposed system or extensions, including all manholes, catch basins, valves, etc. Transverse sections of all sewers over twenty-four inches in diameter shall be submitted.

Specifications.—Specifications shall be submitted covering all work to be undertaken in the proposed system or extensions.

All plans, general plans, detail drawings and specifications shall be accompanied by affidavits stating that the plans, drawings and specifications so submitted are those to be used and followed in the construction of the proposed system or extensions.

Sewage Disposal Works and Extensions.—A report shall be submitted, prepared by the engineer acting for the municipality, giving information under the following heads, in so far as such are applicable to the proposed works:—

1. Population—The present population and the rate of increase during each of the past five years. Available data justifying an increase of population and probable increase in next ten years.
2. Maximum population which system will provide for if fully developed.
3. Population provided for by proposed works.
4. Water consumption in municipality per capita per 24 hours.
5. Estimated maximum rate of flow of sewage arriving at works, expressed in gallons per hour.
6. Estimated daily flow of sewage arriving at works.
7. The number of connections already made to sanitary sewerage system.
8. The character of the sewage (with reference to surface and roof water, trade wastes, etc.). Any excess over domestic sewage shall be estimated in gallons per hour under: (*a*) Roof water; (*b*) surface water; (*c*) infiltration water; (*d*) trade waste water.

   In the case of trade discharge the character of the waste shall be given.
9. The distance and location in relation to the works of any wells or underground source of water supply. In the case of the final effluent discharging into a watercourse or lake, it shall be stated whether such watercourse or lake is, or eventually becomes, a source of domestic supply or is used for watering cattle.
10. Minimum volume and velocity of stream or river into which the final effluent will be discharged.
11. Area of land acquired for sewage disposal purposes.
12. Character of subsoil through which sewerage system is laid, with particular reference to the presence of sand.
13. Character of treatment processes to be adopted.
14. Type of sewage lifts to be used at sewage disposal works.
15. Provision for dealing with sewage in the case of failure of sewage lifts.
16. Type of screens and provision for the removal of screenings.
17. Preliminary precipitation of mineral particles—velocity of flow in detritus tanks.
18. Type of sedimentation tanks, capacity and velocity of flow in tanks, inclination of base of tanks.
19. Method of drying sludge and final disposal.
20. Capacity of dosing or siphon chamber.
21. Type of filter beds; character, area and depth of filter media. Rate of filtration. Method of distribution over surface of media.
22. Retention of humus.
23. Disinfection of effluent.

24. Provision against frost.

25. Location of bypasses.

26. Provision for measuring and recording flow of sewage.

27. Future extensions.

28. Provision for grading, surfacing, etc.

29. Control and operation.

In the case of extensions to existing works, the report shall, in addition to describing the nature of the proposed extensions, deal with as many of the above matters as are thereby affected.

Estimates of Costs.—A statement prepared by the engineer shall be submitted showing the estimated cost of the proposed works or extensions. The estimated cost of each section of the work (e.g., land, pipe lines, sedimentation tanks, filter beds, mechanical appliances, buildings, etc.) shall be shown separately. The estimated cost of operation per annum shall also be given.

General Plans.—The following plans shall be submitted:—

(*a*) Location Plan.—A location plan to a suitable scale showing:

1. The location of the works in relation to the site of municipality.

2. The route of the main outfall sewer.

3. The layout of the various units of the sewage disposal works, including all drains, pipe lines, etc.

4. The area of land to be utilized for sewage disposal purposes.

5. The lake, watercourse or subsoil, into which the final effluent will be discharged.

6. Elevation of high, mean and low water in watercourse or lake.

7. Highest known flood elevation of watercourse.

8. Elevation of effluent drain at point of discharge and of outfall sewer at entrance to works.

(*b*) Sketch Plans.—Preliminary sketch plans shall be submitted to a scale which shall indicate the type and capacity of the various tanks, filter beds, etc.

The principal elevations and measurements of the various parts of the works shall be indicated on these plans. Such preliminary plans shall give sufficient information to enable the commissioner to arrive at a conclusion as to the efficiency of the proposed processes of treatment and design, and structural details may be omitted therefrom. Sketch plans need not be submitted if the detailed drawings required by section (4) accompany the application.

Detail drawings shall be submitted to a scale which shall clearly indicate the design of all parts of the proposed works. Longitudinal and transverse sections of all tanks and filters shall be shown.

Profiles of all pipe lines and drains shall be submitted drawn to a suitable scale.

Specifications shall be submitted covering all work to be undertaken in the proposed system or extensions.

All detail drawings and specifications shall be accompanied by affidavits stating that the drawings and specifications so submitted are those to be used and followed in the construction of the proposed works or extensions.

In addition, there is a set of general regulations applicable to the above respecting dimensions of drawings, samples, records, etc. A penalty is attached covering violation of the regulations.

Schedule A.

Location	Between	Size of pipe	Character of pipe whether steel, cast iron, etc.	No. of existing buildings requiring water	Average depth of trench	Length in feet	Cost of pipe laid complete per lin. foot	Total cost

Schedule B.

Location	Between	Size of pipe	Character of pipe whether fire-clay, concrete, etc.	No. of existing buildings requiring drainage	Average depth of trench	Grade %	Length in feet	Cost of pipe laid complete per lin. foot	Total cost

Schedule C.

Location	Between	Size of pipe	Character of pipe whether fire-clay, concrete, etc.	Average depth of trench	Grade %	Length in feet	Cost of pipe laid complete per lin. foot	Total cost

Some of the building contracts of engineering importance which are at present in progress at London, Ont., are the construction of two public schools at about $50,000 each, the Dominion Savings building at $200,000, the Wellington Street Methodist Sunday School, $12,000, a building for the Ford Motor Company to be used for the assemblage of cars and for a warehouse, $50,000; the reconstruction of the Princess Avenue School, $30,000; a large addition to the St. Joseph's hospital, and the reconstruction and enlargement of the Collegiate Institute

Recent reports state that the Illinois Central Railway has placed orders with the Pressed Steel Car Co., the American Car and Foundry Co., and the Standard Steel Car Co., for 2,000 cars, which will make a total of 5,000 purchased by that railway in June. Other orders reported are one from the Wabash Railway Company for 60 locomotives from the American Locomotive Co., and one from the Seaboard Company to the same engine builders for 30 locomotives. June has proven to be a considerably better month for steel manufacturers than did either April or May.

REPAIRING LEAKS IN AN 8-INCH MAIN 40 FEET UNDER WATER.

About two years ago a water main of 8-inch cast iron pipe with lead caulked flexible joints was laid across Galveston Channel, which is the waterway lying along the wharf front at Galveston. It extended from the wharf front, where it connected with the city water main, to the pile dike on the north side of the channel, a distance of 1,400 feet, thence was laid in a shallow trench along the dredge spoil bank. The portion across the channel was laid in a trench 40 to 100 feet wide, dredged to a depth of 41 feet across the entire width of the channel, which was then about 30 feet deep for 500 feet of its 1,400 feet width. Cast iron pipe was used with flexible joints of the ordinary ball-and-socket type, which allowed a deviation from a straight line of about 12°. The ordinary lead caulking was used with yarn packing. The greater portion of the line was laid by caulking up and lowering one pipe at a time, the line of pipe being carried on an inclined trough from the barge nearby to the bottom of the trench and the barge being fleeted forward as the line lengthened. Soon after the laying was completed and water had been turned into the main, leaks began to develop due partly to the method of laying and to the uneven character of the bottom, which caused such a great deflection at each joint that the lead caulking was squeezed out, and to the fact that the line

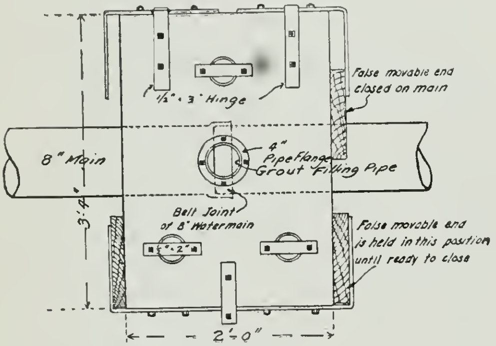


Fig. 1.—Top Plan of Form Used in Repairing Water Main.

was caught by a ship's anchor before completion. Efforts were made to recaulk the leaky joints by the aid of a diver, but these efforts were unsuccessful as it was found the pipe was deflected at these points to such an extent as to close the caulking space on two sides. After considerable thought and investigation, a method of stopping the leaks was evolved which has proven entirely successful. The method is described by Mr. N. T. Blackburn in the July-August issue of Professional Memoirs of the U.S. Army Corps of Engineers, as follows:

The method was simply the placing of a wooden box form around each joint and filling this form with neat Portland cement grout. Each form was supported on three 3-inch pipes, 14 feet long, driven down through holes in the forms into the underlying clay so as to form a pile foundation and prevent any settlement at the joint due to extra weight.

The form, shown in detail in the accompanying drawings, is 3 feet 4 inches square by 2 feet deep, hinged at one edge so that it opens diagonally. In the top is a 4-inch hole with a pipe flange for connecting a 4-inch pipe extending to the top of the water, and through which the grout was poured from the barge into the form. To the front of the lower half was fastened a chain which helped close it and held it closed afterwards, one link being let over a hook attached to the upper half and screwed up until form closed tight. In either side, where main passed through, a square hole 18 inches by 18 inches was left in order that the form would close no matter if the joining pipes were at their greatest possible angle, either vertical or horizontal. A movable section consisting of two pieces, 2 inches by 12 inches by 3 feet, each cut out in the form of an 8-inch semi-circle to take half of the main, closed around the main, tightly covering and at the same time entirely closing the 18-inch square holes. These false ends work outside of the form and are held in position by iron straps under which they can move in any direction against its side. Three holes large enough to take 3-inch pipe were bored through the top and bottom of the form for the piling. They were so bored that two piles would go on one side of the main and one on the other. After the pipe piles were driven down through the form flush with the top, a one-half inch iron plate was laid over the top of the pile and bolted to the form to carry the weight until the cement set around the piling.

The trench in which the main lies had been partly refilled with clay thrown into it by a dredge and by the natural deposit of sand, mud, and silt carried in by the cross currents and tides. This filling was partly removed with a 20-inch suction dredge, but fear of disturbing the main kept the dredge from working closer than about 4 feet of its top. After the dredging was done the water was cut off the main, air pressure put on and leaks were located by the air bubbles coming to the surface of the

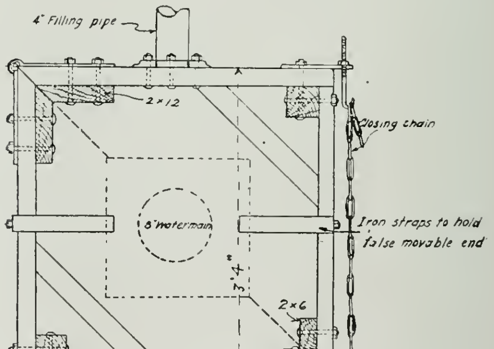


Fig. 2.—Side Elevation of Form.

water. All leaks of any consequence were marked by dropping a weight into the hole blown through the mud over a leak by the air and carrying a line ashore from the weight. It was not safe to use buoys for marking the leaks, as they were liable to be carried away by ships and all leaks had to be located and marked before repairs were commenced as the air pressure had to be taken off the line and kept off until the cement was thoroughly set.

The plant used consisted of a derrick barge and a barge with an 8-inch belt-driven sand pump. A diver was in constant attendance.

The method of placing the form and filling with grout was as follows: The barges were anchored at the leak and the overlying sand and mud first pumped off the pipe. Then to the flange coupling on the form was connected a 45-foot length of 4-inch pipe. Three rope lines were fastened to the front of the lower jaw of the form, one to the end of the closing chain and one near each side. The diver then took all three of these lines down around under the main and back up on the barge where a man was stationed at each line. Then, as the form was lowered away by the derrick with a line from the 4-inch pipe, the men took in on these lines and the lower half of the form, which dropped open when the form was picked up, was guided into place under the main. By lowering the upper half the form was closed. The piling was then set in the holes provided in the form and were driven flush with the top and the iron straps bolted over them. A jet was then put into the form through the 18-inch square openings and any mud in the form driven out and the joint thoroughly washed off. A piece of raveled, loose rope yarn was then tied securely around the leak to keep the cement

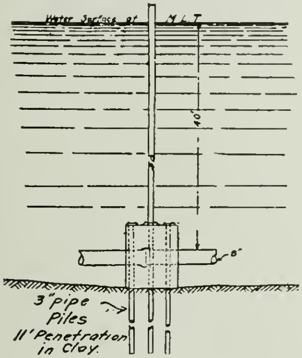


Fig. 3.—Form in Place.

from entering the main. The false forms over the ends of the form were then driven into place around the pipe and the form was ready for cement. The cement was mixed with salt water to a thickness that would just pour through a funnel into the 4-inch pipe leading down into the form. It was found necessary to pour it slowly in order to give it time to settle. Displaced water went out of the form through the holes around the piling in the top of the form. When the form was filled, the nuts on the bolts in the flange union fastened to the form were taken off and the 4-inch filling pipe removed, and the job was finished.

On the last leaks which were closed, pouring the cement through the pipe was abandoned owing to too much lost time in waiting for it to settle. The pipe, however, was still used to lower the form and to hold the form in position until piling were driven. After this it was taken off and the cement, which was mixed as thick as possible, was lowered down to the diver in buckets and poured into the form through the hole at which the pipe had connected.

Where the soft mud and silt was so bad that it could not be kept out of the form, a 4-inch centrifugal pump with a flexible suction end was used to clean out the form after it was in place and all closed, the mud being pumped out through the cement filling hole while a jet alongside stirred it up. In the work of closing these leaks it was found necessary to have the pipe and inside of the form absolutely clean, so that the cement would adhere to the pipe. It was found necessary to take the form off the first leak and do the work all over again, as mud had been pocketed in the grout.

When repairs were completed, all cement was allowed to set a week. About 40 pounds of air pressure was then put on the main and kept on for over an hour. During this time not a single air bubble could be seen and the water meter showed the leaks had been stopped.

Four leaks were repaired and the entire work was executed in about four weeks, including the time of assembling plant, dredging, building forms, etc. By actual time a form was lowered and fastened around the pipe in forty-five minutes. To close the false end gates of the form required fifty minutes. To drive the piles required from one to one and a half hours, depending on how hard the driving was. To mix the cement and fill the form required one hour and fifteen minutes. The total cost of the repair work, closing four leaks, was $2,300.

CARE OF RAILWAY BRIDGES.*

BRIDGE work is a perpetual and continuous job like track and all other classes of railroad work, but the kind and amount of the different varieties of the work changes with the seasons. In the winter surveys should be completed and plans made for future work, and maintenance should be kept up at the least possible expense. Light construction work should be dropped while heavy construction work on abutments, piers, and mass concrete can be pushed to advantage, especially in localities where the ice is strong enough to be of assistance in handling the work, and also where low water is necessary.

In the spring all bridges should be closely inspected and the necessary repairs ordered. Various methods for making inspections are in vogue. The general inspection may be annual or semi-annual, and be added to by periodical local inspections. When semi-annual, the fall inspection is made with a view of seeing that everything is in shape for the winter and to decide on the construction or heavy maintenance work to be considered and investigated for the next season's operations, while the spring inspection is for the purpose of planning and starting the work to be done in the immediate future.

On many roads the bridge engineer makes the general inspection of the large bridges and permanent work, while the inspection of the smaller temporary or wooden structures is left to the local officers. On at least one of the large western roads this process is reversed and the bridge engineer inspects the temporary structures yearly, leaving the permanent structures for the local officers. Possibly it would be well for bridge engineers to combine the two methods and inspect all bridges.

The maintenance and construction forces should be built up and work started as early in the spring as possible so that the beginning of summer will see the work well under way. All pile drivers, machinery and tools should be overhauled and repaired; material ordered, delivered and unloaded, and complete preparations made so that once work is started it can be pushed ahead without delay. A definite programme in the delivery of material to each bridge or each job of work should be outlined and insisted on so that there need be no delays waiting for material, and it should be so arranged that gangs can fully complete each job and then go to the next job without any delay.

*Railway Age Gazette.

The summer is the season for doing the systematic work of repairing, renewing, filling or replacing with permanent structures every bridge on the line as it may need. The work is done by gangs of various sizes which may be either permanent or extra gangs as the work may demand. The pile driver is generally handled by a regular gang, although the method of having each bridge gang educated so that it can also handle the pile driver is sometimes advocated. However, as each road tries to get along with a minimum number of pile drivers so that it is desirable to keep them working at their maximum efficiency at all times, this latter method is of doubtful economy.

On account of the scarcity of foremen and of labor and the advantage of getting work done immediately with as little travelling as possible the combining of the bridge work with section work, signal work and other maintenance work is beginning to be advocated. There are many strong arguments in favor of this and should it be found successful it is likely to reorganize our entire maintenance system and methods. The past 15 years have witnessed very radical changes in the construction of permanent waterway openings due to the use of concrete and steel, and the future will be likely to add to these and thereby also change our methods of maintenance.

As temporary bridge structures are replaced by steel and concrete the amount of maintenance work is very materially decreased. Bridge gangs are replaced with carpenter gangs, painters' gangs, plumbing gangs, etc., as development of the country necessitates. The building up of towns and cities makes it necessary to do much more work around the station grounds than formerly, and the quality and kind of work varies with the nature of the public improvements. Sewers, pavements, permanent platforms, water supplies, plumbing, electric lighting, electric power and other features of latter day progress make it necessary for the railroads to employ specialists who can best handle the necessary work.

Small jobs of construction work and indeed all construction work that it is possible for them to handle should be done by the regular maintenance organization, but large construction jobs require a separate organization which should be flexible as to size and which can be moved from place to place as exigency requires.

Permanent structures in the past have been largely put in by contractors, mainly for the reason that the railroads have not had the necessary equipment for handling the work. However, as they have become larger and permanent work has become more general, it is now becoming customary for the railroads to do their own masonry and steel erection work. Whether they save money in all cases by doing this is questionable, when the cost of the equipment with interest and depreciation is taken into consideration. Undoubtedly where construction work is continued from year to year requiring permanent forces, outfits and machinery, they save the contractor's profit, but in many cases the amount of work and the inexperience of the men makes the cost more to the railroad company, although this fact may not be evident on the surface of their accounts.

During the summer months all the bridge work should be pushed to completion as rapidly as possible, so that in the fall all that remains to do will be to get every bridge and opening in shape for the winter. This not only means that its strength and condition should be cared for, but that the waterways themselves, including the channels and ditches, should be clean and free from obstructions, so that there will be a free flow of water to and from the openings, that the openings may fulfil the purpose for which they were constructed.

As most of the railroads in this country were constructed in a time when timber was cheap, many pile and trestle bridges and timber culverts were built which are being replaced more or less rapidly with permanent structures. This has been accelerated of late years by the use of concrete and the consequent cheapening of the permanent openings. The life of the timber bridges has also been lengthened in many cases by the use of creosoted timber. This material is especially applicable in cases where the bridge decks have to be replaced oftener than the piles, and many years are often added to the life of the bridge by the use of a creosoted deck which may be filled in and ballasted.

When the original timber bridges were built, but little attention was paid to the size of opening required to properly carry the water, so long as it was large enough.

With permanent structures this is not a sufficient rule on account of the greater cost, and the size of openings should be proportioned to the use required of them. This makes necessary complete surveys and investigations of the bridge, its drainage area and outlet. These surveys should be made or started as early in the fall as possible, so that time may be had for considering each bridge and designing the necessary structure, culvert or pipe for the opening in order that the material may be ordered and delivered in time for the next summer's building.

In considering the amount which can profitably be spent for replacing temporary with permanent structures, the first cost of the temporary bridge should be taken together with such an amount as will, when put at interest at current rates, provide for its maintenance and periodical replacement at such times as it may wear out. A common wooden pile bridge can be replaced by a permanent reinforced concrete pile bridge on a ratio at present-day prices of about 3 to 1, while there are many cases of bridges or trestles which can be replaced by reinforced concrete culverts, boxes or pipes for even less than the cost of a wooden structure. The use of reinforced concrete for many railroad structures is growing rapidly and merits the full investigation of every railroad engineer. Pipes, culverts, boxes, highway bridges, subways and overcrossings, arches, trestles, bridges and retaining walls are now being permanently and cheaply constructed of this material, to say nothing of buildings, tanks, coal chutes and other uses for which it is being rapidly adopted.

RAILROADS OF BRITISH COLUMBIA.

It is estimated that during 1913, 650 miles of new railway, not including double-tracking, were laid in British Columbia, of which 285 miles are credited to the Grand Trunk Pacific, 212 to the Canadian Northern, 75 to the Kettle Valley Railway, 65 to the Canadian Pacific, 19 to the Esquimalt and Nanaimo Railway, 18 to the Pacific and Great Eastern, 5 to the Victoria, Vancouver and Eastern, and one-half mile to the Western Canada Power Co. There were also 66 miles of double-tracking, 59 of which is credited to the Canadian Pacific, and 7 to the Victoria, Vancouver and Eastern.

It is announced in the Scientific American that earthquake construction has now reached a very practical stage in the seismic districts of Italy, where all new buildings are being erected under strict supervision with regard to their ability to resist earthquake shocks. Professor Omori, the Japanese authority, has estimated that 99.8 per cent. of the deaths in the great Messina earthquake of 1908 would have been prevented if the buildings had been properly constructed.

A METHOD OF FIGURING REACTIONS FOR CONTINUOUS BEAMS.

By I. F. Morrison, S.B.,
Lecturer in Structural Engineering, University of Alberta.

The subject of continuous beams has received considerable attention in several of the latest text-books. The methods usually employed, however, are not, in all cases, conducive to their practical application. Only a limited number of cases for different loadings can be found already worked out and for this reason a rigid application of the theory is often avoided in practice. Rapidity, accuracy and ease with which results are obtained, are the requisites of any engineering practice, and it is hoped that the following method will promote all of these, as well as stimulate those who are interested to add more to what is here presented.

The general equation for the theorem of three moments for beams of constant modulus of elasticity and moment of inertia can be written as follows: (See article by Prof. Slocum in the Engineering News, Feb. 19, 1914.)

$$M_1l_1 + 2M_2(l_1 + l_2) + M_3l_2 = -\Sigma P_1 l_1^2(k_1 - k_1^3) - \Sigma P_2 l_2^2(2k_2 - 3k_2^2 + k_2^3) - 6EI\left(\frac{h_1 - h_2}{l_1} + \frac{h_3 - h_2}{l_2}\right);$$

where E is the modulus of elasticity and I the moment of inertia of the sectional area. The remaining notation may be obtained from Fig. 1.

If the supports are on the same level, and the load P_1 is unity and P_2 is zero, then the formula becomes:

$$M_1l_1 + 2M_2(l_1 + l_2) + M^3l_2 = l_1^2(k_1 - k_1^3).$$

If P_1 is zero and P_2 is unity, it is,

$$M_1l_1 + 2M_2(l_1 + l_2) + M_3l_2 = l_2^2(2k_2 - 3k_2^2 + k_2^3)$$

In applying these equations to any particular case an influence line may be plotted for the various values of k which lie between 0 and 1. Take the case of a continuous girder with two equal spans. Consider the load of unity in the first span only. Since $M_1 = 0$ and $M_3 = 0$

$$2M_2(l + l) = l_1^2(k_1 - k_1^3)$$

$$M_2 = \frac{l}{4}(k_1 - k_1^3).$$

$$\text{Then, } l\,R = \frac{l}{4}(k_1 - k_1^3) + l\,(1 - k_1).$$

$R_1 = 1 - 5/4k + \frac{1}{4}k^3$ upwards
$R_3 = \frac{1}{4}(k - k^3)$ downwards
$R_2 = \frac{1}{2}(3k - k^3)$ upwards.

The following table gives the values of R_1, R_2, and R_3 for values of k from 0 to 1 with the load of unity in the first span only:

k	R_1	R_2	R_3
.0	+1.0000	+ .0000	—.0000
.1	+ .8753	+ .1495	—.0247
.2	+ .7520	+ .2960	—.0480
.3	+ .6318	+ .4365	—.0683
.4	+ .5160	+ .5680	—.0840
.5	+ .4062	+ .6875	—.0937
.6	+ .3040	+ .7920	—.0960
.7	+ .2108	+ .8785	—.0893
.8	+ .1280	+ .9440	—.0720
.9	+ .0572	+ .9855	—.0427
1.0	+ .0000	+1.0000	—.0000

From this table the influence line shown in Fig. 2 may be plotted.

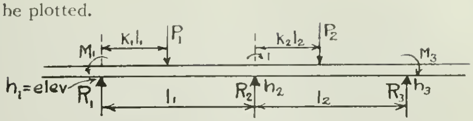


Fig. I.

In this case it is not necessary to work out a table for the unit load in the second span because the curves are symmetrical, as may be seen in the figure. Since the influence line for any particular number of supports and ratio of spans is always the same, after it is once plotted it may be used to solve problems for any loading.

Problem 1.—Consider a continuous girder with two equal spans, with a uniformly distributed load of w pounds per linear foot over both spans. Since the product of the ordinate to the influence line at any point and the load at that point will give the value of the reaction for which the influence line is drawn, it is only necessary, in this case, to find the area under the curve. The areas below the horizontal axis are considered to be negative areas.

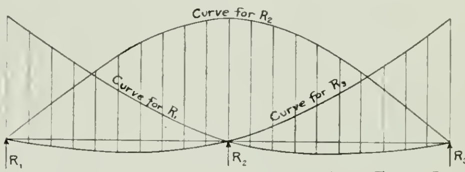


Fig. 2.—Influence Lines for Reactions. Two Equal Spans.

For those who are familiar with the calculus, it is sufficient to say that the area may be quickly obtained by integrating each curve from $k = 0$ to $k = 1$. This will be found to give the well-known values:

$R_1 = \frac{3}{8}wl$ upwards,
$R_2 = 5/4wl$ upwards,
$R_3 = \frac{3}{8}wl$ upwards.

The following graphical method is found to be more convenient as well as useful. It consists of drawing a curve such that the ordinate at any point will give the area under the influence line between the ordinate and the reaction R_1. This curve, which has been called the area curve for the lack of a better name, is also the same for any particular number of supports and ratio of spans and therefore when once obtained may be applied for any loading. The influence line is plotted first, as shown in Fig. 3, and each ordinate has been multiplied by w. The

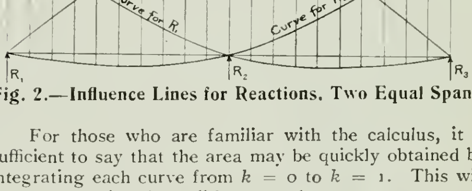


Fig. 3.—Area Curve for R_2.

middle ordinate is then drawn for each strip and horizontal lines are drawn to intersect the vertical ordinate at R_2. R_1 is chosen as a convenient pole and a new curve is constructed, as shown by drawing a string parallel to each ray in turn until it intersects the ordinate which bounds each strip on the left. The last ordinate on the new curve

is the total area under the influence line. In this case it is 1.25 w on the same scale as the ordinates to the influence line. From this R_2 = 1.25 wl, as given above. R_1 and R_3 may be obtained in a similar way from Fig. 4.

If the area curve has been drawn, as has been done in this case, for w = 1, then any distribution of uniform loading may be dealt with as follows: Lay off on the span the part which the uniform load covers and draw the ordinates at each end to the area curve. The difference in value of these ordinates multiplied by the loading per linear foot between the ordinates multiplied by the span in feet will give the reaction for that loading. The area curve for R_1 and R_3 is shown in Fig. 4, and has been constructed in the same way as that for R_2 in Fig. 3.

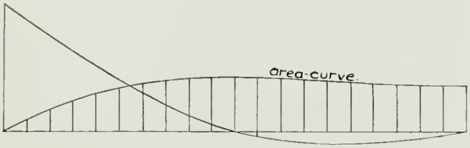


Fig. 4.—Area Curve for R_1.

In dealing with concentrated loads the ordinate to the influence line multiplied by the load at the ordinate will give the reaction. Each load is considered separately and the results added to obtain the total reaction.

Problem 2.—Consider a continuous girder of two equal spans of 12 feet and loaded as shown in Fig. 5.

To find the centre reaction R:

From the area curve (Fig. 3) the difference in ordinates at
k = 1/12th and k = 6/12ths the span from R_1 is + .180
k = 2/12ths and k = 11/12ths the span from R_2 is + .460

The ordinate to the influence line (Fig. 2) at
k = 9/12ths the span from R_1 is - - - + .918
k = 8/12ths the span from R_2 is - - - + .470

+ .180 × 200 lb./1 × 12′ = + 432
+ .460 × 100 lb./1 × 12′ = + 552
+ .918 × 500 = + 459
+ .470 × 200 = + 94

R_2 = Total = + 1537 pounds upward for the loading given.

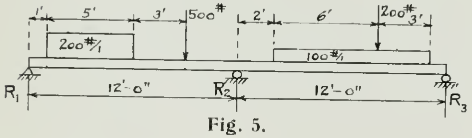


Fig. 5.

To find the end reaction R_1

From the area curve (Fig. 4) the difference in ordinates at
k = 1/12th and 6/12ths the span from R_1 is + .261
k = 2/12ths and 11/12ths the span from R_2 is —.061

The ordinate to the influence line (Fig. 2) at
k = 9/12ths the span from R_1 is - - - + .166
k = 8/12ths the span from R_2 is - - - —.078

+ .265 × 200 lb./1 × 12 = + 636
—.061 × 100 lb./1 × 12 = — 73
+ .166 × 500 = + 83
—.078 × 200 = — 16

R_1 = Total = + 730 pounds upward for the loading given.

To find the end reaction R_3

In this case the curves in Fig. 4 must be reversed or the loading and reactions may be reversed. Therefore, take R_3 to the left.

From the area curve (Fig. 4) the difference in ordinates at
k = 1/12th and 10/12ths the span from R_3 is - + .347
k = 3/12ths and 11/12ths the span from R_2 is - —.034

The ordinate to the influence line (Fig. 2) at
k = 8/12ths the span from R_2 is - - - + .595
k = 9/12ths the span from R_1 is - - - —.058

+ .347 × 100 lb./1 × 12 = + 417
—.034 × 200 lb./1 × 12 = — 82
+ .595 × 200 = + 119
—.058 × 500 = — 29

R_3 = Total = + 425 pounds upward for the loading given.

To check the work, the sum of the three reactions must be equal to the sum of the vertical loads.

Sum of vertical loads = 2,600 pounds downward.
Sum of reactions = 2,592 pounds upward.
Error - - = 8 pounds.

From this it will be seen that the error made by using this method, with no more than ordinary care, is well within the limit allowable for practical work. The diagrams used were drawn to a small scale. Greater accuracy may be obtained by using a larger scale, though a very large scale is not to be recommended because the accuracy of the graphical construction decreases rapidly when the scale becomes excessive.

PRODUCTION OF CASINGHEAD GASOLINE IN CALIFORNIA.

Estimates made recently in connection with the development of casinghead gasoline, as the fluid extracted from wet gas is called on the southern Pacific coast of the United States, show that the production will have increased by the fall of this year about 40 per cent. over what it is now, and, it is believed, nearly 100 per cent. in the next 6 months.

The present output of all the plants in California exceeds 20,000 gallons per day. Compressors are operated in all parts of the state, except in the Midway field. It is only recently that the first compressor plant was installed in Coalinga field, on the Turner Oil Company's property; and this has proven to be a very successful one, turning out about 2,000 gallons daily. Other plants throughout the state are yielding from 500 to 2,000 gallons per day.

At present the Union Oil Company in Santa Maria field is making additions to its plant, so as to give it a capacity of 8,000,000 cubic feet of gas per day. This compressor plant will cost nearly $500,000, and, it is said, will be the largest in the world. Further enlargements are being made also in the Santa Maria field on the plant owned by the Rice Ranch Oil Company and on that of the Purity Gasoline Company, so that, when completed, the former will be capable of producing 2,000 gallons a day and the latter 1,500 gallons.

All this is shown in contrast to the fact that two years ago, in the state of California, about 1,000 gallons per day represented the total output of casinghead gasoline.

The product is very high-grade and is mixed with one to one-and-a-half parts of distillate before it is used commercially. Consequently the production secured for commercial purposes may practically be estimated at 50,000 to 60,000 gallons a day, worth at present wholesale prices about $600,000. The value of the casinghead gasoline output, untreated, is lower, being about $300,000.

Mills Brothers, Toronto, now have their office at 215 Ryrie Bldg., not in the Lumsden Bldg., as stated in a recent issue.

Editorial

TRACKAGE REQUIREMENTS OF INDUSTRIAL ENTERPRISES.

One of the chief problems in connection with factory construction is trackage. We are disposed to term it a "chief" problem for the reason that in designing a layout for factory and industrial enterprises it often happens that neither the architect, engineer nor owner gives the matter of trackage much thought. He relies on the supposition that after the land has been acquired and the building erected the tracks can be run into it without trouble. This is a serious oversight, as an important factor in the success of an industry is the quick and economical handling of the raw material to the factory and of the finished product away from it.

As Mr. G. H. Herrold, C.E., of the Civil Engineers' Society of St. Paul, remarked when discussing Mr. King's paper, appearing, in part, in this issue: "A first-class factory poorly erected with reference to trackage, resulting in awkward switching facilities, is only half a factory."

In designing such trackage, it is necessary for the engineer to be familiar with the daily car requirements of the establishment and also with railway switching methods in general and the particular switching services to be obtained at this point. It is sometimes stated that designers of factories have little conception of permissible grades or curvature for practical switching. This often results in requiring additional land for right-of-way, and a track longer than necessary. Sometimes it also requires the building of trestle work or the making of excessive fills in order to bring the track to the factory at the proper level and give a length of track along the factory, which should be level to permit the hand-shifting of cars, if necessary, during the day.

That the tracking problem is not given some attention by our designing engineers of factories is, of course, generally untrue. Nevertheless, it forms a vital part of factory equipment and constitutes requirements to suit the individual case. The simplest track possible is one switch and a stub track running along the factory, which may serve the purpose for small outputs, although a double-end track is more desirable, as it facilitates better handling of the cars. If the nature of the industry is such as to require a different class of cars for the finished product than for the raw material, arrangements should be such that empties and loads can be placed at the factory doors in the morning in the order required and the loads and empties removed from the other end of the track in the afternoon without disturbing any cars not yet unloaded or being loaded. If the business of the factory is sufficient to require two or more tracks, one should run at each side of the factory, one for raw material loads only and the other for loading and outgoing loads only. This is in line with the general tendency of factory design to begin its processes at one side of the factory and deliver the finished product on the other side, eliminating cross-handling as much as possible.

Referring to the remarks of Mr. Herrold, the economical design of factory buildings involves the following problems in approximately the order given:

A study of the processes to be carried on in the factory.

The design or selection of the machinery.

The layout of the machinery and determination of floor space.

The layout of yard room.

The determination of the daily car requirements.

The investigation of switching service in the locality selected for location.

The design of the track layout desired.

The fitting of buildings and tracks to the ground owned or available by actual surveys.

The general revision of all plans to compromise with conditions.

LONG CONCRETE ARCHES.

In the progressive march of science and engineering there occurs, at intervals that possess a semblance of periodicity, epoch-making events whereby the veil of familiarity is lifted to display before the world some superlative achievement, surpassing all others existent in its class, but almost inevitably destined to experience, some day, the event of being itself similarly surpassed. The literature of the engineering profession makes frequent reference to some new enterprise which is, for a brief period of time, "the largest in existence." Bridges, tunnels, dams, ocean liners, sky-scrapers, canals, hydro-electric power developments, etc., have all at one time or another taken advantage of our susceptibility to regard them, unthinkingly, as the last word in their particular line of engineering enterprise. The frequency of such occurrences, however, has come to be a mark of engineering activity throughout the world.

The design and construction of reinforced concrete bridges serve as an illustrative example of this progress. Since the beginning of the 20th century there have been a dozen or more occasions to refer to some new and surpassing construction throughout the various countries.

In *The Canadian Engineer* for June 27th, 1912, an article was published describing the Ponte del Risorgimento, which, with its arch span of 328 ft. in a 33-ft. rise has for several years maintained its distinction as being the largest reinforced concrete arch in the world. It was built in 1911 over the Tiber in Rome, and its design was noteworthy in that at its crown the thickness of the arch is only 8 in., increasing to 20 in. at the springing lines. Stiffening ribs, 8 in. in thickness, extend throughout its entire length.

This bridge over the Tiber has resigned its distinctive greatness to an arch which is now being constructed at Langwiez, Switzerland, and which has a 330-ft. span. This bridge, however, unlike its predecessor in design, is of massive construction, with a rise of nearly one-half of its length.

The Ponte del Risorgimento, noted above, had taken the title from the Grafton bridge in Auckland, New Zealand. This was a reinforced concrete structure with a 320-ft. span and a rise of 86 ft. begun in 1907 and completed in 1910. The Munro Street bridge in Spokane, Wash., also of concrete, had a span of 285 ft. and a rise of 117 ft. For a list of long concrete arches giving dates of erection, principle dimensions, etc., the reader is referred to *The Canadian Engineer*, Vol. 22, No. 26, page 843.

ECONOMICAL DESIGN OF INDUSTRIAL WORKS.

THE economical design of factories involves the solution of a large number of simple engineering problems and requires a broader knowledge of engineering than most types of buildings. The designer should be an engineer. He should have a fair working knowledge of architecture as well as of civil, structural, mechanical and electrical engineering, and he should acquire a clear understanding of the particular machinery to be installed and the processes to be carried on in the construction he is setting about to design. It is the work of an industrial engineer rather than an architect, but the former should not minimize the importance of the architectural requirements of the work and devote all his attention to the considerations of economy of construction and efficiency of operation. Although the æsthetic considerations are not as important, they should be given due consideration.

In a paper presented to the Civil Engineers' Society of St. Paul by W. E. King, C.E., and published in the June issue of the Association of Engineering Societies, the work of the industrial engineer in the design of industrial structures is discussed and the problems relating thereto are outlined in order to give a general view of the economics of this form of construction. The following is extracted from Mr. King's paper:—

The first consideration is the proper locality for the industry. This is largely an economic problem, which the engineer may or may not be required to study.

The cost of any manufactured commodity to the retailer consists of the following items: Cost of raw materials, cost of the transportation of these raw materials to the factory, cost of labor on materials, cost of power, overhead charges, including interest on money invested, depreciation of plant, insurance, office time and advertising, cost of distribution, profit to the manufacturer.

Assuming the price to be received for any finished commodity to be fixed by competition, then that project which will pay the largest profits, is, of course, the one where the sum of the first six charges is a minimum. This does not necessarily mean that any one item should be reduced to a minimum, but that the sum of all the items taken together is the least possible. The usual difficulty is that some one man almost always plans each project with the idea of reducing some one item to a minimum. For instance, a man who has spent the larger part of his time in handling of workmen will insist that the plant be so located that there will be an abundance of cheap labor. If he had at one time been a purchasing agent he would plan his plant to save all freight possible on raw materials. The sales manager is interested in the location of the factory with respect to the market. The man who furnishes the money is sometimes unduly interested in cutting the first cost down to a minimum, without regard to whether the interest on his money might be larger if more money were invested.

It should be the duty of the engineer to study these questions and to so present them that they will occupy their proper rank of importance. This rank is, of course, different in different kinds of factories. In the fabrication of structural steel, for instance, perhaps the most important factor is freight. This includes freight from the rolling mill to the factory and freight on the finished product from the factory to the consumer. In some parts this freight amounts to more than half the cost of the finished product.

Where freight is one of the chief considerations, charts may be prepared showing the zone in which a product may be profitably marketed. The boundary of each zone will be determined by considering the sum of the freights on raw and finished materials for the proposed location as compared with other possible locations. The properly prepared chart will show the overlapping territories where competing factories sell on an equal basis. It will show the area where the factory in question has the advantage, and it will also indicate the areas which cannot profitably be reached.

The matter of available market probably reaches its greatest importance when the capacity of a profitable factory is about to be increased. It may be that the selling organization is now reaching all of the profitable market zone, and that to increase the sales the product must be marketed at a disadvantage.

Some industries use large amounts of fuel or power, which requirement is the determining factor in their location. In connection with this there is a tendency to group factories around water-power sites, which will probably not be as marked in the future, because our modern methods of electrical transmission allow power to be economically delivered at a considerable distance.

Having determined on the vicinity where the factory is to be built, the next consideration is the purchase of the exact site necessary for the project. The exact area of land which is necessary is usually a troublesome one. Most successful projects are hampered by lack of room to provide for their growing needs. On the other hand, it is a serious handicap to a young industry, to be burdened with heavy interest charges and taxes on land not at the time in use.

The size and shape of the area necessary for present needs is usually determined by making a preliminary plan of the whole project. If the engineer be unfamiliar with the need of the industry in question, this will usually involve quite an extended study of the methods of manufacture used by the particular organization and of similar organizations in other places. If, however, the designer has already prepared plans for other similar plants, the tentative preliminary plans involve only a study of the peculiar requirements of the special case. This preliminary plan should, of course, take in the reasonable growth of the industry, which usually may be approximately obtained by a comparison with similar industries in other communities. With the approximate area required clearly in mind, a search of the locality will usually show a number of available sites. For projects of some importance, plats are usually prepared showing how the proposed sites may be developed. These plats should show the approximate grades and elevations of all adjacent streets, the location of sewer, gas, water and power connections and the available connection to adjacent railroads or sidetracks. If grading of streets or of the lots will be necessary, this should be estimated and added to the comparative price of the lots. For the purposes of comparison the cost of the sidetrack, including necessary grading, the cost of sewer, water, gas and power connections should be obtained. Very often the owners will buy a lot first, without considering the cost of these things, which must be added to make the lot available, and in so doing they fail to get the most economical site. Plats showing the proposed sidetrack should be submitted to the railways interested and assurance should be had from their engineering and contracting departments that they are willing to put in the desired connection. If the sidetrack must cross the public road it is just as well to be sure of the permit before putting money into the lot.

Sidetracks.—At this time a study should be made to determine the number and length of sidetracks which will be required. In general, the track should be long

enough to hold as many forty-foot cars as the company will need to load and unload in any one day. In isolated places, where the cars are not set as often as that, the sidetrack must be long enough to allow for all the unloading and loading which must be done between each setting by the switch engine. Sidetracks for loading and unloading should in general be level. The rules of the railroad in question, of the state and interstate railway commissions and the state labor laws are the determining factors in the amount of room required for sidetracks.

Building Plans.—After the exact location of the site is determined, then the plans of the buildings may be prepared. It is a mistake to make the final plans of any building before its definite location is settled. The natural grades of the land itself, the streets, the points of the compass and the condition of the subsoil almost invariably change the plans to such an extent that they must be revised or redrawn. All of these conditions should be determined by an exact survey before work on the plans commences.

As before stated, the basis for the design of the factory building should be a complete understanding of the processes to be carried on in the building. Too many factories are built first and the machinery just put in, one piece at a time, after the building is completed. This usually results in the uneconomical use of the floor space, unused spaces occur in some parts and a congested condition results in other parts.

The first plans to be prepared should be complete machinery plans. A study should be made of the progress of the materials through the shop. In general, the manufacturing processes should be so arranged that there will be no lost motion. The various materials which go to make the finished product should all travel through the various parts of the factory in such a way that they will arrive at the assembling-room without having travelled any greater distance and without having been transferred more times than is absolutely necessary. Leaving the assembling-room, the materials should go by the shortest possible route to the storage and shipping-rooms. This part of the work is, of course, best planned with the prospective superintendent of the shop. It is sometimes difficult to get the benefit of this man's detailed knowledge and experience without letting his narrowness of viewpoint blind the designer to the broader phase of the question.

As a rule, a good factory superintendent has spent the larger part of his life in some one factory. He probably has made that factory a success. That leads him to think that he knows all there is to know about that business. At least he thinks he knows more than any engineer whom the owners can hire. That is generally true, but his difficulty is that he is so close to his job that his perspective is warped. For instance, if ten years ago he tried a belt-conveyor in his factory which he bought and installed improperly himself, and then afterward abandoned because it did not do the work required, he is convinced that he does not want a belt conveyor in his new factory. The fact that belt-conveyors have been improved since he tried them and that there are thousands of them working satisfactorily under similar conditions will impress him only if you can overcome his prejudices. If you can make him feel that he and the engineer are working together to get the best possible design and that you realize the value of his suggestions, then, generally, it is possible to get him to listen to yours.

The building should be built to suit the machinery. The columns and beams, the height of stories, the location of heating and plumbing pipes, the sprinkler system, the natural and artificial lighting should all be arranged to suit the machinery.

The economical arrangement of the structural parts of the building should also be taken into consideration in the arrangement of the machinery. If possible, the columns should not be spaced to suit special machines unless there is some very decided advantage in doing so. It must be remembered that the life of a building is several times the life of the machinery installed, and that the machinery of the future may be entirely different.

Types of Factory Buildings.—There are two types of factory buildings which are here considered separately. The first is the ordinary one-story building with a hip-roof, which may or may not be surmounted by a monitor. It usually has large, unobstructed floor space to provide for the movement of cranes and other large machinery. The second type is the warehouse type of one or more stories in height. Industries which require a clear floor space of more than twenty-five feet in either direction are usually housed in one-story buildings, because it is expensive to carry the weight of upper floors on long spans. Where the materials manufactured are of such size that columns spaced from sixteen feet to twenty-five feet on centres are not objectionable the building of several stories is usually more economical.

A one-story building costs the most per sq. ft. of floor area. This cost per sq. ft. of floor area decreases somewhat with the number of floors built, up to four stories. Above that height the cost per sq. ft. gradually increases. There is comparatively little difference in the cost per sq. ft. of the floor area between a three and an eight-story building.

If basement floor space is suitable it is the cheapest which can be obtained, except where the loads to be carried on the first floor are extremely heavy. A one-story shop building in fireproof construction will cost from from $1.25 to $2.00 per ft. of floor space area, depending upon the height of the story, depth of footings, length of spans and kind of exterior finish used. Fireproof buildings of more than one story may be built for as little as fifty cents per square foot of floor area. These approximate figures do not contemplate any sort of plaster or interior finish except whitewash. They do include a properly finished cement floor. The cost per sq. ft., of course, decreases as the size of the ground plan increases. It is more for a long, narrow building than for a square building. However, a factory building should not be made too wide on account of the difficulty in properly lighting the interior. For ordinary factory work from 40 to 50 ft. is the best width. A building of this width can be lighted with a story height of from 12 to 14 ft. If the width of the building be made from 75 to 100 ft., then the story height should be increased to from 14 to 16 ft., the windows being placed as high as possible.

One-story shop buildings are usually built of what may be termed semi-fireproof construction. They are usually built of materials which will not burn, but cannot be said to be entirely fireproof, because the steel trusses are usually left unprotected, so that they might be damaged in case of fire occurring in the contents of the building. As before stated, the one-story plan is usually adopted where large, unobstructed floor spaces are required. This results in long-span steel trusses supporting the roof.

The most common type of roof is the "A"-shaped roof. This roof has many advantages. It is easy to keep watertight, it clears itself of snow easily, and with monitors or ventilators at the peak provides good ventilation for the factory. If these monitors are made wide enough

and are provided with windows they admit considerable light, but if the building is high and wide, monitor windows usually do not admit a satisfactory light.

A better type of roof, where light is essential, is the sawtooth roof. This roof is made up of a series of pitched roofs, rising towards the north and stepping down with a vertical step, in which windows are installed. These windows, facing towards the north, admit a diffused light, which illuminates the floor below without casting shadows. If the windows in the sawtooth construction are arranged to swing, they provide as good ventilation as the old monitor type. The disadvantage with sawtooth construction is that it presents a number of valleys where snow may lodge. In some cases steam pipes have been installed to melt the snow. This serves the purpose, but is rather expensive. In buildings where there is considerable steam in the air condensation gutters are necessary under monitor and sawtooth windows.

Roof.—The most unsatisfactory problem in shop building is probably the roof. It first must be watertight; second, if the building is to be heated in winter, it must be of such material that condensation will not occur on the under side; third, it should be fireproof; fourth, it must compete with a large number of cheap roofs which are lacking in one or all of these qualifications. A standard roof construction consists of three-inch hollow book tile, laid on steel tees. This tile is covered with some good prepared roofing, which is cemented and tacked to the tile. This roof is very expensive, but it fulfills all the requirements stated above. It costs, including supports, about thirty cents per square foot.

Another good roof is 2-inch dressed and matched sheathing, laid on wood or steel purlins and covered with a good prepared roofing. It is just as good and much cheaper than a book tile roof, but, of course, is not fireproof. It will cost about 20 cents per sq. ft., including supports.

In some instances a thin concrete slab laid on steel or concrete purlins has been used. Considerable condensation occurs under such a roof in cold weather. Furthermore, it is very difficult to keep a tin roof slab from being damaged by frost while being laid in cold weather.

If the shop is not to be heated in winter time, corrugated iron laid on steel purlins makes a very inexpensive fireproof roof, costing about 12 cents per square foot in place, including supports. It is fairly watertight, but, of course, is very cold in winter.

There are, of course, many other kinds of roofs, but the price for any roof comes between the limits here given.

There is not so much choice in the materials of construction of the side walls of a building as the roof. They may be of brick, stone, concrete, corrugated iron or glass. In this vicinity brick is the most usual and satisfactory material. Buildings with high stories are usually made with steel frames, the walls being simply curtain walls bricked in between the columns. Hollow brick should be used for the inside layer of brick to prevent condensation of the side walls.

Concrete for side walls is more expensive and less satisfactory than brick. Concrete blocks are sometimes used, and are probably all right where enough cement is put in the blocks. Such walls are, however, weak, due to the lack of bonding between the blocks.

A 12-in. common brick wall in this part of the country will cost about 38 cents per sq. ft. in place. With a good facing brick and some architectural decoration the cost may be increased to from 40 to 60 cents per sq. ft.

In the modern factory building the question of material of the outside walls is not an important feature, because from 75 to 100 per cent. of the wall area is occupied with windows and doors. The old style shop building did not, as a rule, admit enough light. Our new buildings probably admit too much. It is a mistake to assume that a workman needs as much light to work by as there is out under the open sky. Too much light is almost as bad for the eyes as too little. Most of the inconvenience of working indoors comes from working with a strong light from one side which casts shadows. Windows should be so arranged that light will reach every point from at least two directions and be of as near the same intensity in both directions as possible.

Another question upon which there is usually some argument is the kind of windows to be used. The three types most in use are the standard wooden sash, the rolled steel sash and the fire underwriters' sash of sheet steel or copper. The underwriters' sash is very little used for shop buildings because of the expense. They will, however, greatly reduce the insurance rate upon such walls of the building as have a bad fire exposure.

The most satisfactory sash at the present time, for factory work, is the rolled steel sash. This is a comparatively new product, having been on the market for only a few years. Where large areas are to be glazed the small size of the steel muntins and mullions permits the maximum amount of light to enter the building. Several factories have been built with the side walls almost entirely of glass, the only obstructions in the walls being the columns and the brick work at the floor line. Steel sash have a few disadvantages which should be taken into consideration. The ventilation is usually secured by pivoting a part of the sash near the middle. In factories where screens are necessary it is not possible to have ventilation because the screen will not permit the ventilator to swing. In this northern climate storm sash are desirable because of the loss of heat through the glass by conduction. Steel sash are too heavy and too expensive to use for storm sash. If wooden sash be used the advantages obtained by the use of steel inside sash are lost.

The cheapest sash to use is undoubtedly the double hung wooden sash with which we are all familiar.

Four General Classes.—Factory buildings of more than one story naturally divide themselves into four general classes, according to the materials of which they are constructed. This classification is really made by the fire underwriters inasmuch as the different types take different insurance rates. In fact, the rate of insurance is the consideration which most often determines the type of construction.

These classes are, frame construction, slow burning timber construction, structural steel and reinforced concrete.

In the frame construction class should be included all buildings having either brick or timber walls, wherein the floors are of wood and the joists narrow and spaced close together. Such buildings are, of course, the cheapest which can be built. By far the larger number of the present factory buildings are of this type. When an industry is in an experimental stage and the process of manufacture and the machinery are likely to be changed with experience, it is more economical to build in this manner. If a building is anything more than a temporary structure the extreme fire hazard, the danger to employees upon the upper floors and the lack of rigidity for supporting machinery are disadvantages which should be taken into consideration.

In the slow-burning mill building construction, as described by the fire underwriters, the walls must be of

brick or stone. It differs from the frame construction in that the joists are spaced from 3 to 6 ft. apart and are timbers of considerable size. The floors are matched planking. All stair and elevator hatchways must be enclosed, with doors at each floor opening. This construction is, of course, somewhat more expensive than the frame construction. Its principal advantage is that it takes an insurance rate about 20% less than frame construction.

Any timber construction has several advantages over more permanent types such as concrete or steel. Alterations in the buildings, due to changes in processes of manufacture and the installation of new machinery, are much more cheaply and rapidly made. The expense of attaching shafting and machinery to the finished structure is considerably less. Wooden buildings are more rapidly constructed than either reinforced concrete or structural steel buildings.

The columns in buildings with wood beams should be spaced from 12 to 18 ft. on centres. If a greater column spacing than this is required it is usually more economical to make the beams spanning in the longer direction of steel. These beams may rest on cast iron or steel columns, the remainder of the construction being of wood.

A better construction consists of steel columns and beams throughout. The floors may then be made of reinforced concrete or tile. If the columns and beams are then covered with fireproof material such as tile or concrete the building may be regarded as the best type of building which modern civilization has produced. In such a building the steel columns do not occupy so large a percentage of the floor area as do concrete columns. Exact stresses in a steel frame building are more easily computed. The chance for variation in the strength of the material due to faulty workmanship or design is not nearly so great. Alterations of the building are more economically made in a steel than in a concrete building.

The most popular type of factory building in many localities is reinforced concrete. A properly designed concrete building is the very best building which can be put up for many industries. It is entirely fireproof and takes the same rate of insurance as a fireproof steel building. Such buildings are probably the most rigid type which can be constructed. The material will stand a large amount of abuse in the way of faulty workmanship and design. Other types of buildings deteriorate with age, but a concrete building increases in strength. So far as we are able to determine at this time, our concrete building will be as good in the structural parts fifty years from to-day as they were when built.

The floor spans of a concrete building may economically be made from 16 ft. to 24 ft. in length. The exact span for minimum cost, of course, depends upon the expense of the foundations. The more expensive the foundation piers the longer may be the economical span. We find that the flat plate type of column pier is considerably less expensive than the old-fashioned masonry piers of the pyramid type.

The statements made concerning the exterior walls of one-story buildings are, of course, true in regard to buildings with a greater number of stories. It is usually economical to build self-supporting exterior walls for buildings up to three stories in height. For buildings higher than three stories the walls are often made twelve inches thick and carried upon the steel or concrete frame of the building.

The details of the work which have been described in the foregoing paragraphs are interesting in illustrating the method by which we try to arrive at the final economical design. A factory is made up of such a large number of details that only a few can be touched upon at this time. The arrangement of electric lighting and the ventilating systems, so as to give each worker sufficient air and light, are other interesting problems.

Finally, it may be said that in the last analysis the most economical factory building is the one where each worker is given the best conditions for doing his work, for the least cost.

UNION STATION, TORONTO.

The contract for the construction of the new Union Station for the city of Toronto was awarded last week to the P. Lyall Construction Company, of Montreal and Toronto, the amount of the contract being approximately $4,000,000. The station is being built by the Toronto Terminals Railway Company, Mr. J. R. W. Ambrose, chief engineer. Messrs. J. M. R. Fairbairn, assistant chief engineer, C.P.R., and H. R. Safford, chief engineer, G.T.R., are consulting engineers to the organization formed for the purpose of handling the enterprise.

The new station will be constructed on a site east of the present building and will be bounded on the north, east and west by Front, Bay and York Streets respectively. The site forms a portion of the fire-swept region which has remained for the most part unoccupied and desolate since the conflagration of 1904.

Messrs. Ross, Macdonald and Jones are the architects with whom is associated Mr. J. M. Lyle, Toronto. The erection of the new Union Station will form a part of a $15,000,000 development project which includes a large amount of grade separation to be affected along the water front.

REINFORCED CONCRETE SEWER AT VICTORIA, B.C.

A reinforced concrete sewer is under construction in Victoria, B.C., that will drain a section of the city 425 acres in extent; also, 800 acres in Saanich and 1,000 acres in Esquimalt. It will be two miles in length when completed, and will empty into an outfall near Macaulay Point, where it will discharge through several hundred feet of steel pipe at a point below water level where the tides admit of unusually favorable disposal. The trunk sewer is 27 in. in diameter at its beginning, increasing to 36 in. at the outfall, and the sections of reinforced concrete pipe are cast in 5-ft. lengths.

The excavation for the sewer consisted of about 7,250 ft. of rock tunnelling and 3,100 ft. of open work. The tunnel work attains a depth of 65 ft. below the surface, and consists essentially of three separate tunnels, the first of which is now being driven and in connection with which two shafts have been sunk. The tunnel is being constructed 5 ft. in width and 7 ft. in height. The excavated material is for the most part solid rock, and admits of an average progress of 5 ft. per day. The work is in charge of Mr. A. E. Forman, assistant to City Engineer Rust.

Another notable reinforced concrete pipe line in Victoria is that in connection with its water supply. It is a 28-mile conduit, 42 in. in diameter, and is being constructed by the Pacific Lock-Joint Pipe Co., of Tacoma.

Coast to Coast

Prince Rupert, B.C.—The G.T.P. Railway officials expect to have the big dry dock at Prince Rupert completed before the end of the present year.

Edmonton, Alta.—Work on 137,000 square yards of paving and concrete sidewalks will commence almost immediately. The work will cost in the neighborhood of $400,000.

Windsor, Ont.—As a result of the decision handed down in the High Court in Toronto, all work on the city's new incinerator plant at Windsor has been abandoned temporarily.

Brantford, Ont.—It is reported that by August 1 negotiations will have been completed, and both the Brantford Street Railway and the Grand Valley Railway will belong to the city of Brantford.

Moose Jaw, Alta.—A recent report states that the C.P.R. line of 70 miles from Kerrobert to Monitor, Alta., will be completed shortly. This will establish through connection from Moose Jaw to Lacombe, Alta.

Halifax, N.S.—Telephonic communication with Prince Edward Island on a commercial basis was formally inaugurated on July 7. The new cable was laid by the Maritime Telegraph and Telephone Company.

East York Township, York County, Ont.—It was announced at the meeting of East York township ratepayers that the construction work on the hydro-electric power line extension up the Don road would be commenced immediately.

MacLeod, Alta.—It is expected that the Calgary MacLeod branch line of the C.N.R. will be completed this season. The new line will run directly north to Red Deer, continuing north several miles west of Lacombe and Edmonton to Athabasca Landing.

Brandon, Man.—No definite decision was arrived at by the Railway Commission at its recent sitting in Brandon in reference to the city's application for an order directing the Grand Trunk Pacific Railway Company and the Canadian Northern Railway Company to establish joint terminals in Brandon.

Saskatoon, Sask.—A great many gas and oil leases have been filed during the past few weeks at the Dominion lands office in Saskatoon. The district in which the lands leased are located is an area of over 60,000 acres, partly in the Hanley district and partly in the townships on the boundary or near the Hanley district.

Victoria, B.C.—Arrangements have been completed by the contractors, Messrs. Grant, Smith, and McDonnell, for the immediate shipment of rock to the piers under construction by that firm at Ogden Point from the new quarry which has opened up at Esquimalt. More rapid progress will now be made upon the work.

Hamilton, Ont.—The works committee of the Hamilton council has decided to recommend to the board of control that a by-law be submitted next January to ratepayers regarding the purchase of a stone quarry, as well as with reference to the offer of the Canada Crushed Stone Corporation to supply stone to the city at from 85 to 90 cents per ton.

Winnipeg, Man.—A communication from the Dominion public works department to the Winnipeg and St. Boniface harbor commission, stated that parliament has granted the sum of $200,000 for harbor improvements to be effected on the Red River at Winnipeg and St. Boniface. Work on the docks is to be commenced and carried on as rapidly as possible.

Victoria, B.C.—According to the assertion of H. E. Beasley, general superintendent of the E. and N. Railroad, the opening of the line for service will take place between July 25 and August 1. The construction of the Trent River bridge has been completed, and the laying of rails and ballasting is practically completed into Courtenay, the temporary northern terminal of the line.

Weyburn, Sask.—Within the coming year, the town of Weyburn expects to acquire connection with three railways. The C.N.R. has promised construction of a link to that centre. Through trains from Winnipeg to St. Paul to be operated over the C.P.R. cut-off to Vancouver are now definitely promised. And the G.T.P. is already completing plans for opening up the territory to the southeast of Weyburn, and the position of the town as a distributing centre is expected to be assured.

Montreal, Que.—The G.T.R. Company has completed the installation on the Victoria Jubilee Bridge across the St. Lawrence River, a new type of automatic train signals, which is the first of the kind to be used in Canada. The new apparatus, known as the alternating current, 3-position semaphore, consists of eleven signals, the total length of the first line covered being 3½ miles. It replaces the Hall banjo type, which was installed in 1902 and which was at that time the first automatic signal put in use in Canada.

Vancouver, B.C.—The plans for the Dominion Government drill hall, which is to be erected at Vancouver at a cost of $350,000, have been completed by Perry and Fowler of Vancouver, and are now on inspection. The building measures 278 by 174 feet. The drill hall proper, measuring 225 feet by 120, will extend up to the roof of the building with a sweeping arch above. It will be well lighted and ventilated. Surrounding the drill hall on the main floor will be company armories and officers' rooms. The basement will provide a swimming pool, gymnasium, miniature rifle range and bowling alleys as well as ordinance store rooms, armory repair shop and sheds of different descriptions.

Chatham, Ont.—Chatham is experiencing considerable difficulty in arriving at a solution to its power problem. The Chatham Gas and Electric Company has refused to accept the proposition recommended a short time ago by the Hydro-Electric Commission that the city purchase the plant of the gas company for the sum of $410,000. The last offer of the company to the city is to reduce the rates of electricity to a basis equal to the probable rate that Hydro power would be sold at in Chatham, run the plant for 10 years, and then take the accrued profits and turn the plant over to the city without the expenditure of a dollar. The city council is now considering the advisability of accepting this proposition.

Montreal, Que.—At the Maisonneuve plant of the Canadian Vickers Company will commence on August 1 the construction of what will be the second largest icebreaker in the world, and will cost $1,000,000. It is to be used by the Canadian Government for icebreaking in the river and gulf of St. Lawrence, and is to be launched next May. It will be of the heaviest type of construction, will carry a crew of 90 men and will have the following dimensions: length, 292 feet; width, 56 feet; draft, 19 feet. It will be equipped with 8,000 horse-power engines. To form the launching ways between 800,000 and 900,000 feet of southern pitch pine is being brought to Montreal from Georgia in a vessel which sailed for Montreal on July 4th.

St. Hyacinthe, Que.—Within 35 miles of Montreal, across the St. Lawrence River, and close to the town of St. Hyacinthe, drillers are boring for natural gas under the direction of the promoters, the Canadian Natural Gas Company. The company has secured the right to operate throughout the counties

of St. Hyacinthe and Richelieu, an area of 250 square miles. One well was sunk to a distance of 1,860 feet, and produced a flame when lighted of from 75 to 100 feet in height, giving a pressure from a 2½-inch pipe, of approximately 600 pounds to the square inch. Encouraged by this success, the company extended its operations and have now almost completed the sinking of another well. The power for operating the machinery for this second well comes from the gas flowing from the first. It is the company's intention to sink a third well this summer, so as to ascertain definitely the extent of the "find."

Squamish, B.C.—The P.G.E. Railway Company has appointed Mr. J. Cumming in full charge of all the harbor and railway development work to be carried out by the company at Squamish. The harbor work will involve changes in the channel at the mouth of the Squamish River at its entrance to the Sound. The plan is to alter the course of various channels in such manner as to bring the river up against the base of the mountain and thus reduce erosion. The entire plans for this big undertaking will not be finished for several months, but in the meantime it will be possible to proceed with filling and banking work, and the clearing of the Indian reserves recently acquired by the company at Squamish. The reserves contain altogether 1,100 acres, from which should be deducted 200 acres of steep mountain sides. Besides these 900 acres, however, the company is filling in 200 acres of tideflats on the southwest waterfront of the old townsite of Newport. Wharves and waterfronts are to be laid out by Mr. Cumming, as well as a wide boulevard on one side of the old townsite.

Winnipeg, Man.—It has been announced that the administration board of the Greater Winnipeg Water District will call very shortly for tenders in connection with the various works in connection with the 84.72 miles of aqueduct for the Shoal Lake water project, which will cost approximately in totum $8,729,000. Advertisements are to be placed in journals in Canada, the United States, England, France, and Germany. Last year a division of cost of the work was made by the consulting engineers of New York and Boston as follows:—1,880,000 cu. yds. earth excavation west of the Summit Cut, at 60c., $1,116,000; 1,100,000 cu. yds. earth excavation in Summit Cut, at 75c., $825,000; 94,000 cu. yds. of rock excavation, at $2.50, $235,000; 2,300,000 cu. yds. refilling and embankment at 40c., $920,000; 340,000 cu. yds. concrete at $13.00, $4,420,000; 29,000 cu. yds. reinforced concrete at $17.00, $493,000; 13,000 ft. timber platform at $40, $520,000; steel for reinforcing aqueduct, $70,000; special work at and near river crossings, including waste weirs, $80,000; gate and screen chamber and other works at intake, $50,000; total for concrete aqueduct and appurtenances, $8,729,000.

Victoria, B.C.—An announcement has been made by J. S. Maclachlan, Government resident engineer, to the effect that by the end of July, the first signs of the Ogden Point breakwater, being constructed by Sir John Jackson, Limited, will appear above water. Previously, difficulty has been experienced in the laying of the granite boulders which form the foundation, owing to the inclined surface of the sea bottom at the inner end of the breakwater. But the work has advanced, nevertheless, satisfactorily; and, according to the engineers' statistics, the weight of granite blocks laid since the operations were started amounts to 3,677 tons. Throughout the month of June the divers placed in position a total of 1,199 tons. June has also been a record month in the dumping of rubble on the breakwater site, 60,606 tons having been dumped. This exceeds that of the previous month by 10,000 tons. The total amount of rubble now dumped is placed at 373,608 tons, which now comes to within 20 feet of low water as far as the final stretch, or the last 700 feet of the breakwater. An idea of the work which has been done may be gleaned from a consideration of the base of the breakwater, which is 200 feet in width and tapers up to a height of 72 feet. The contract is so far advanced that actual operations will be started this month on the concrete work forming the superstructure of the great sea wall. At the present time 1,250 barrels of cement have been delivered on the site by the Associated Cement Company, of Bamberton, which has been awarded the contract to supply all the cement necessary for the breakwater. Before being used this cement is to be given a 28-day test. The leveling off of the wharf area is now practically complete, 1,717 cubic yards having been leveled off last month. And the fifth and last of the dolphins has been driven, marking the extreme end of the sea wall.

Vernon, B.C.—A publication from Vernon states that July will see the commencement of construction on the branch line of the C.N.R., running from Kamloops to the Okanagan Valley. The Hon. Price Ellison, provincial minister of finance, has signed the $5,110,000 guarantee passed by the British Columbia Legislature in February; and the Hon. Mr. White, Dominion minister of finance, has signed the guarantee of the Dominion Government to the C.N.R. amounting to $45,000.000. The $50,000,000 worth of bonds which have thus been made available are to be marketed at once in England. Operations will be begun simultaneously at three points, Vernon, Armstrong and Kamloops. From Vernon construction work will proceed in four directions; from Vernon toward Armstrong, toward Kelowna, toward Okanagan Landing, and up the White Valley toward Lumby and Shuswap Falls. The entire branch line will be about 148 miles in length. From Kamloops to Vernon the survey is 81 miles long, from Vernon to Kelowna 35 miles, from Vernon to Okanagan Landing about 4 miles, from Vernon to Lumby 17 miles and from Lumby to Shuswap Falls 10 miles. The last named 10-mile extension is not included under the recent guarantee, but will be built to reach the company's power site and townsite at the falls, where electric power is to be developed to operate the Lumby and Kelowna lines and probably the entire line through to Kamloops. Active development work on the power site will probably not be begun until next spring. But in every way possible, the work will be hastened; and grading, with the exception of the few heavy pieces of rock work on the Kamloops-Okanagan line, is expected to be practically completed by January 1, 1915. In connection with the section from Vernon to Okanagan Landing, the C.N.R. plans to build a lake fleet of passenger steamers and freight barges, which will increase the traffic from this district.

PROGRESS OF CONSTRUCTION ON THE P.G.E. RAILWAY.

A report upon the work done up to date upon the P.G.E. Railway, was made recently by A. H. Sperry, general manager of the railway company, to D'Arcy Tate, vice-president of the company, and to the Premier of British Columbia, Sir Richard McBride. Mr. P. F. Welch, of the firm of Foley, Welch and Stewart, the contractors for the railway construction, has chief charge of the work, and has in his employ 5,600 men. The work on the road is being rushed as fast as possible to an early completion. It is planned to have the grade work completed all the way to Fort George this year, before the frost enters the ground. It is stated that an excellent standard of efficiency is being maintained in every detail of the work along the entire 810 miles of length of the railway from Squamish to Peace River, via Fort George. Mr. Sperry reported that for a distance of 13 miles from Vancouver, grading and tracklaying have been completed and

that on July 1 next, a local service will be inaugurated in that section of the country.

There is a gap of some 20 miles between Horseshoe Bay and Squamish, where heavy rock work will be necessary. This section will be left by the construction gangs until all the other portions of the contract between Fort George and Vancouver are well on towards completion. It will then be undertaken and promptly finished.

Between Squamish and Clinton, where the heaviest work has been encountered, the grade is all but completed. Steel is laid as far as Cheakamus River; and as soon as the bridge is completed at this point, steel will be laid right through to the Pemberton Meadows country, and thence through to Lillooet.

It is intended that ballasting shall go on simultaneously with operations of construction, so that the road will thus be put into operation with the minimum of delay. There has been considerable delay in the section of Cheakamus, but this part of the line necessitates the construction of 12 bridges.

After passing the Pemberton Meadows, the track has been continued to cross the Fraser at Lillooet. Here a further delay of a few weeks will ensue to permit of the building of a large bridge. The piers for this structure are already in place; and once the bridge is finished, the laying of track will continue to Clinton and above that point.

In November next, Mr. Sperry expects that construction will have advanced to such a degree of completion as to permit of the inauguration of a mixed train service from Squamish to Lillooet, a distance of 120 miles, this run being made in five or six hours. Mr. Sperry has already placed orders for a large amount of rolling stock, which is to be utilized in equipping the road for regular traffic. This equipment is to be thoroughly modern and up-to-date, so that the railway service will not be excelled by that of any other transcontinental system in Western America.

PERSONAL.

GERALD PONTON, C.E., of Calgary, has been in England during the past month investigating the various methods of road building.

ARTHUR SURVEYER, of Surveyor and Frigon, Consulting Engineers, Montreal, is leaving for Europe on August 1st, to attend the "White Coal" Congress at Lyon.

CHAS. HARPER, B.A., of the research laboratory of Queen's University, Kingston, has been appointed professor in charge of the Department of Science at Moose Jaw College.

The Canadian Northern Railway Company announces, from its Winnipeg office, the following appointments taking effect July 5th:—

Mr. I. L. Boomer, Superintendent at Edmonton, (3rd district Western), becomes Superintendent at Calgary (4th district Western Division, newly created).

Mr. J. C. O'Donnell becomes Superintendent at Edmonton, (3rd district Western), in place of Mr. Boomer. Mr. O'Donnell has been promoted from Trainmaster, his headquarters formerly being at Rainy River, Ont., on the 1st district Central.

Mr. M. G. Hurd, formerly Chief Dispatcher at Saskatoon, (2nd district Western), becomes Chief Dispatcher and Trainmaster at Calgary (4th district Western).

Mr. R. Nelson, formerly Chief Dispatcher at Edmonton, becomes Chief Dispatcher and Trainmaster at Edmonton (3rd district Western).

OBITUARY.

The death is announced of Mr. Everett Ketcheson, an assistant engineer on the construction of the Trent Valley Canal. Mr. Ketcheson was drowned in Trent River on July 11th.

From Haileybury comes the report of the death of Mr. Murdock Lloyd, mining engineer of Toronto, from injuries sustained from a boiler explosion at the Tough Oaks Mines at Swastika.

A fatality occurred near Lytton, B.C., on July 6th, when Mr. John Middleton, a member of a Canadian Northern Railway survey party was killed by falling a distance of 70 feet from a ledge of rock.

While taking measurements in a sewer tunnel Mr. Robt. Strathern, a resident engineer, Department of Sewers, city of Toronto, was asphyxiated by illuminating gas which had escaped from a broken main and had flooded the sewer. Several other members of Mr. Strathern's party were overcome and narrowly escaped death. In connection with their removal from the tunnel, and with an attempt to save the life of the resident engineer, is associated the name of Mr. M. P. McDonald, assistant engineer, whose heroic efforts have occasioned great admiration.

COMING MEETINGS.

UNION OF CANADIAN MUNICIPALITIES.—Annual Convention to be held in Sherbrooke, Que., August 3rd, 4th and 5th, 1914. Hon. Secretary, W. D. Lighthall, Westmount. Que. Assistant-Secretary, G. S. Wilson, 402 Coristine Building, Montreal.

WESTERN CANADA IRRIGATION ASSOCIATION.—Eighth Annual Meeting to be held at Penticton, B.C., on August 17, 18 and 19. Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

AMERICAN PEAT SOCIETY.—Eight Annual Meeting will be held in Duluth, Minn., on August 20th, 21st and 22nd, 1914. Secretary-Treasurer, Julius Bordollo, 17 Battery Place, New York, N.Y.

CANADIAN FORESTRY ASSOCIATION.—Annual Convention to be held in Halifax, N.S., September 1st to 4th, 1914. Secretary, James Lawler, Journal Building, Ottawa.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown. Indianapolis, Ind., Secretary.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.—11th Annual Convention; 5th American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau St., New York, N.Y.

In *The Canadian Engineer* for July 2nd, an error appeared in reporting the name of the writer of the article entitled "Laying Outside Hill Roads," appearing on page 108. The author's name is Capt. A. C. Garner and not "Gardner," as appeared.

Volume 27. Toronto, July 23, 1914

Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

SOOKE LAKE WATER SUPPLY FOR VICTORIA, B.C.

A PROJECT TO CONVEY 16,000,000 GALLONS PER DAY THROUGH 27.3 MILES OF REINFORCED CONCRETE GRAVITY PIPE LINE AND 10 MILES OF STEEL PRESSURE PIPE, WITH A 136,000,000-GALLON INTERMEDIATE RESERVOIR.

THERE is some interesting history associated with the present undertaking by which the city of Victoria, B.C., will be supplied with 16,000,000 gallons of water daily through the Sooke Lake system. The question of water supply for the city extends back to 1868, when a system was adopted whereby a private company supplied the city through wooden pipes from a series of wells. Four years later the city began to investigate Elk Lake (see Fig. 4) as a possible source of supply. The official report concerning it estimated a supply of 25 gal. per capita per day for a population of 90,000. A scheme was entered into whereby for many years the city has received its supply from Elk Lake through open gravity sand filters and by a gravity system. Later, a pumping plant was installed, necessitated by fire protection requirements and by increased consumption. As the daily consumption further increased, the level of Elk Lake became lowered considerably and the quality of water impaired. Meantime the Esquimalt Waterworks Co. supplied Victoria West from the Goldstream Lakes. The cost to the city of the former is 2 cents per thousand Imp. gal. and of the latter 6 cents per thousand Imp. gal. Compared with this, the old well system in vogue before the Elk Lake scheme cost the city 0.75 cents per gal.

In July, 1911, the city decided to actively engage without delay upon plans for the extension of its water supply. Sooke Lake, which lies about 18 miles northwest of Victoria, was subjected to careful hydrographic investigation, including the study of rainfall, run-off, contour surveys, determination of area of watershed and possible supply. Owing to the expeditious circumstances, this work was pushed ahead with all speed, and before the end of the year tenders were called for. This procedure was authorized by a by-law which had received the assent of the electors on January 12th, 1911, for the borrowing of $1,500,000 for acquiring and constructing the Sooke Lake water system. In January, 1912, the contract for the construction of the entire work was let to the Westholme Lumber Company, of Victoria, for the sum of $1,169,170, the system to deliver 16,000,000 gal. of water daily, as stated. In April, 1913, after completing 38½ per cent. of the work when, according to contract, 65 per cent. of it should have been completed, the Westholme Lumber Company abandoned the contract and Water Commissioner C. H. Rust thereupon took over the work, to be done by the city, charging the expense to the contractor, as he was entitled to do by the provisions of the contract. The city has since been carrying out the work by day

Fig. 1.—Portion of Reinforced Concrete Flow Line Near Humpback Reservoir.

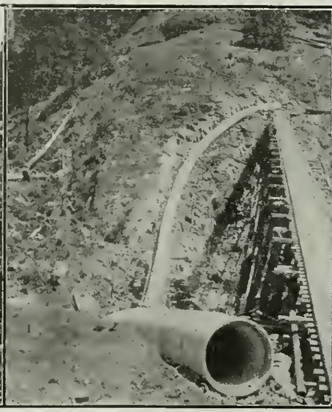


Fig. 2.—One of the Inverted Siphons. Construction railway is also shown.

Fig. 3.—Site of Humpback Reservoir.

labor, with the exception of sub-contracts for the construction of concrete flow line, pressure pipe line, and other small portions.

The scheme constituted the conversion of Sooke Lake into a reservoir with a 12-ft. lift of water level; the laying of a 40-in. reinforced concrete pipe line 27.3 miles in length from thence to Humpback reservoir, about 10 miles outside the city, and the connection of Humpback reservoir with the Smith's Hill service reservoir, in the city, by a 36-in. steel pressure main. This service reservoir has a capacity of 16,000,000 Imperial gal. daily and is located at an elevation of 213 ft. above sea level.

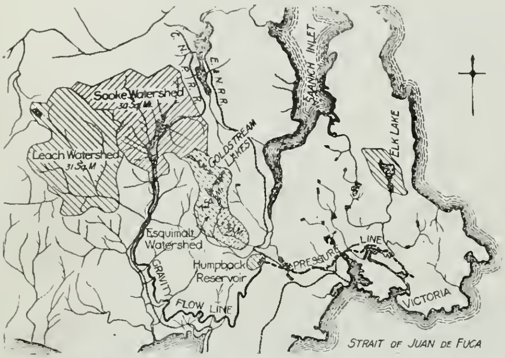


Fig. 4.—Watersheds Around Sooke Lake and General Layout of the Scheme.

Sooke Lake, as stated, is distant 18 miles from Victoria. It is long and narrow, being 4 miles in length and ½ mile in width at its widest point. It is in reality a series of three lakes, the farthest from the city being the largest and having a depth at several points of 150 ft. It has a remarkably pure and wholesome supply of water, outpointing in this respect the other two divisions of the lake. The three sections have an area of 964 acres and the watershed which they drain covers 31.35 sq. miles. At low-water the lake is 342 ft. above normal water level in the city service reservoir. Sooke Lake is fed by a large spring on the west and Ferguson Creek on the east side. The watershed is bounded on the west, south and east by the Leech River, Esquimalt, and Goldstream Lake watersheds, the first and third having areas of 30.33 and 10 sq. miles respectively.

The Sooke Lake water supply scheme includes also the use ultimately of the Leech River supply. It is proposed to build a diversion dam and to bring the water to Sooke Lake through a 5-mile conduit. The dam will have a height of 45 ft. above the present low-water level and will divert a supply equal to 100 ft. per second.

Early construction work entailed the devastation of the shores of Sooke Lake, which were cleared to 15 ft. above low-water level, thereby effecting the destruction of 300 acres of thick forest. It should be stated that the entire watershed is densely wooded with Douglas fir.

The plan and elevation of the Sooke Lake dam, showing the intake tower and channel, is given in Fig. 5. The channel is excavated to 4 ft. below low-water. In the intake tower the water will be controlled by seven sluice gates, four of which are 24 in. x 30 in. and three are 30 in. x 42 in. The gates will be protected by bar screen cages anchored in the concrete. Two 40-in. riveted steel pipes will convey the water from the intake tower to the concrete screen house. In the latter a set of twelve screens of 40 mesh will be installed. Past the measuring weir the water will be conveyed over cascades to the conduit pipe at a grade elevation of 12 ft. below the low-water level of the lake.

The cross-section of the dam is given in Fig. 7, together with a section of the earth-filled portion indicated in Fig. 5. This earth embankment has a concrete core wall bonded into the natural rock.

To the east of the screen house an ogee weir section 200 ft. in length is being constructed. This is also bonded into the natural rock with a cut-off trench at the upstream face. It will average 15 ft. above the foundation.

The reinforced concrete flow line has a reinforcement of wire mesh. It is being built by the Pacific Lock Joint Pipe Company, of Seattle, in 4-ft. lengths with a 3-in. thickness of wall. The contract was awarded to this company in November, 1913, for the sum of $329,760. The 40 in. in diameter is an internal measurement and is calculated to furnish a flow of 16,000,000 Imp. gal. per

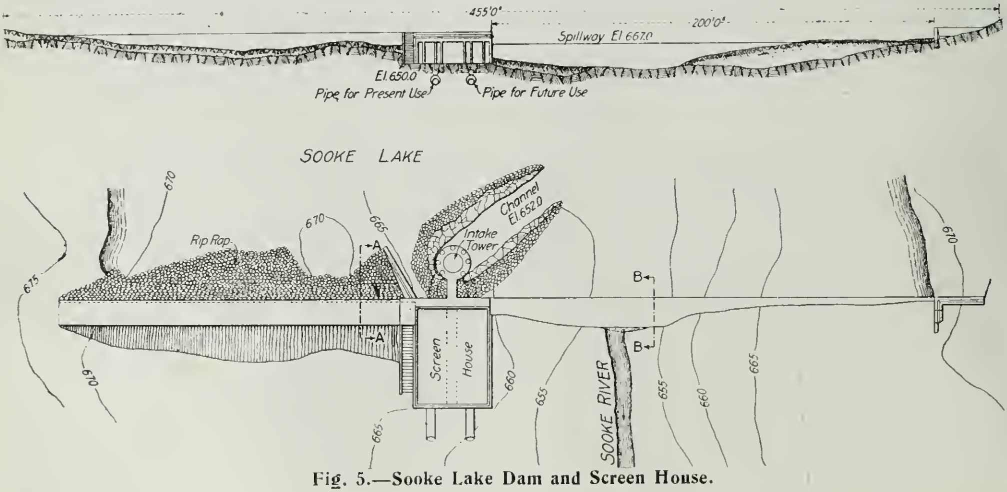


Fig. 5.—Sooke Lake Dam and Screen House.

day, the flow in the pipe being estimated for $C = 120$, in the Chezy formula, or $n = .012$, approximately, in Kutter's formula. The finished pipe is hauled from the site of manufacture at Cooper's Cove (see Fig. 8) by an incline railway to the grade and conveyed from there by the construction railway.

The pipe is laid on crushed stone ballast. The pipe line right-of-way is 100 ft. in width, from which all trees liable to fall upon it have been removed. At every 2,000 ft. on the line is constructed an open standpipe, while all inverted siphons will have steel reinforcement and will have waste outlets at the bottoms controlled by 6-in. gate valves. Fig. 2 shows one of these siphons under construction. There are six of them, the deepest being 600 ft. long with a maximum head of 90 ft.

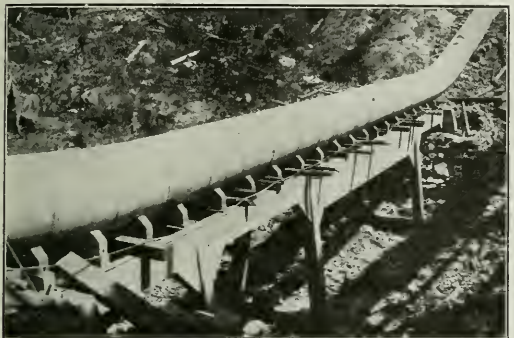


Fig. 6.—Concrete Trestle Carrying Pipe Across Gulley Susceptible to Floods.

In order to protect the flow line from water accumulating on either side, drainage openings of different types are being located where necessity demands along it. Usually the water will be carried along and passed under the pipe line through small holes which penetrate the ballast at points where the roadbed is in the rock. In cases where the volume of water may be considerable concrete side walls will support the pipe, if the span requires it, and also where it needs protection from scour of earthy material underneath. In cases where there is some embankment, drainage will be effected by vitrified pipe varying in diameter from 12 in. to 24 in. Where embankments are unusually large the pipe will be supported by open ravine culverts of about 15-ft. span. Steel bridge spans varying in length from 45 ft. to 80 ft. with concrete abutments will be used to cross transverse streams at low points of the siphons. The pipe line will not be covered except in deep cuts where protection from slides is necessary. Fig. 6 shows a section of pipe line supported by a concrete trestle.

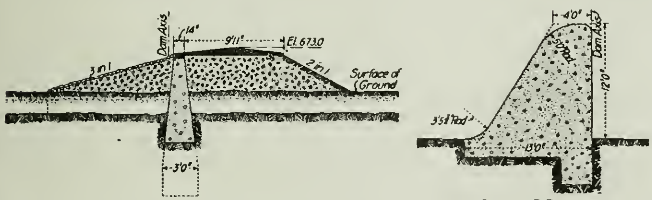


Fig. 7.—Sections of Sooke Lake Dam and Earthfill.

The Humpback reservoir, the site of which is shown in Fig. 3, was decided upon after a good deal of careful investigation. The location of a reservoir at a proper level near the city formed one of the difficulties to be contended with. The reservoir site has an area of about 40 acres and was densely wooded, requiring clearing. The soil is of a black peaty nature. This has been covered with an 8-in. layer of gravel and sand. The material for this covering was procured in the immediate vicinity. The reservoir will have a capacity of 136,000,000 gal., which may be held in reserve in case any accident occur in the flow line pipe. Ordinarily the water will be delivered directly from Sooke Lake to Smith's Hill reservoir through a by-pass pipe. The latter will act as a standpipe, the pressure from Sooke Lake being too great to permit delivery directly into the city distribution system.

Fig. 8.—Site of Manufacture of Pipe Sections at Cooper's Cove.

The dam at the Humpback reservoir has been constructed of concrete. Excavation to a depth of about 30 ft. provided a satisfactory rock foundation. The dam itself has a maximum height of 60 ft., a length of 600 ft., and contains over 8,000 cu. yds. of concrete.

From this reservoir to the city the water supply will be conveyed through a 36-in. riveted steel pipe. Cast iron outlet pipes, two in number and 34 in. in diameter have been installed at the dam for delivering the water to the pressure system. A gate house is provided with control valves, screens, etc. Waste water will be discharged from the dam through a 16-in. cast iron pipe.

The water is to be delivered from the pressure pipe line to Smith's Hill reservoir, which is situated at the southern limits of Victoria. There is a drop of 167 ft. between the two reservoirs. The riveted steel pipe line leading thereto consists of 20,500 ft. 5/16 in. in thickness and 36,500 ft. 3/8 in. in thickness. The pipe sections are about 22 ft. in length; i.e., four plate lengths. The specifications call for plate manufactured by the open-hearth process. The rivets are to be of extra soft steel, pneumatically driven, and the maximum angle of any joint must not exceed 3°. Specifications also call for a pipe coating of bitumastic, or some equally efficient preparation.

A short distance below Humpback dam a recording Venturi meter is being installed. Four concrete gate houses with 36-in. rising stem gate valves will be located along the line and 6-in. gate valves will be provided at

the base of all depressions for use in emptying the pipe. Nozzles providing for corresponding air valves will be inserted in top of the pipe at every summit point. As announced in *The Canadian Engineer* for April 16th, the contract for the construction of this riveted steel pipe line from Humpback to Smith's Hill reservoir was awarded by the city council to the Burrard Engineering Company, the price being $304,000.

The work, since its abandonment by the Westholme Lumber Company, has been carried out under the direction of the City Water Commissioner, Mr. Chas. H. Rust. In July, 1911, Mr. Wynne Meredith was retained as consulting engineer on the project. Mr. Boyd Ehle is resident engineer.

It is estimated that the cost of delivering 16,000,000 gal., which is the maximum capacity of the concrete gravity flow pipe line, including all charges, will be 2¾ cents per thousand gallons. The proposed raising of the dam at Sooke Lake to include the Leech River supply, as outlined in Mr. Meredith's 1911 report, will provide approximately 54,000,000 gal. per day, and will lower the cost to about 1⅓ cents per thousand gallons. It will provide the city of Vancouver with a reservoir storage of 17,358,000,000 gallons from the combined watersheds.

WATER SUPPLY AND SEWERAGE SYSTEMS FOR SMALL COMMUNITIES.

THE benefits to be derived from a public water supply and sewerage system have been brought out very prominently by Mr. W. H. Dittoe, chief engineer, Ohio State Board of Health, in the official organ of the board. The advantages resulting from community life have been recognized since the beginning of history and we are told that in the most remote times the people banded together forming tribes or communities to mutually assist in their own betterment. Out of this tendency grew the ancient town in which the inhabitants were more or less committed to mutual protection. The advantages of community life have progressed with the advance of civilization and learning and in comparison with advantages offered by the modern community those of ancient cities or villages appear insignificant. Community life has its disadvantages, however, and becomes a detriment to the welfare of the people unless necessary municipal improvements are provided. In the present day a community to be considered modern must provide every possible municipal improvement for the convenience of its citizens as well as for its own development and growth. The large cities can, and do, expend great sums of money in providing public water supplies, sewerage facilities, street paving, collection and disposal of waste material, street cleaning, municipal lighting and numerous other public service advantages. This extensive municipal improvement is not possible in the smaller communities, but in every case those improvements which affect the health of the community may reasonably be demanded. In this classification fall public water supplies and sewerage systems. Unless a community can offer the benefits to be derived from such installations the advantages from community life are minimized and overbalanced by the dangers to which the inhabitants are subjected. This neglect results not only in general unhealthful conditions but also in retarding the development and growth of the community.

The installation of a public water supply, which will furnish the maximum benefit to the community, should be the first step taken in the development of municipal improvements. Following the provision of a public water supply and simultaneously with it, if possible, a complete sewerage system should be installed. After these most important improvements have been provided other municipal enterprises may be undertaken as the financial condition of the community will permit.

Public water supplies are obtained from two general sources, namely, from surface streams, lakes or ponds and from underground water-bearing formations. In either case it is well to remember that the original source of the water is the same, namely, precipitation. In spite of the popular belief, not all water supplies obtained from underground sources are suitable for public supply purposes. Water obtained from surface sources is rarely, if ever, to be considered satisfactory in its raw state. In the selection of any source, due attention must be given to the quantity available, for in many cases a disregard of this important factor has led to considerable financial loss. The development of the supply is also of great importance, as upon this may depend the maintenance of the good quality of the water. Proper management and operation of the works after they are installed is a factor influencing the benefits derived from the supply. Also, the advantages of a water supply cannot be fully derived until the supply has come into general use by the citizens. It may be stated that the maximum benefits resulting from the installation of a public water supply can be realized only by meeting the following conditions:

1st. The supply must be of adequate quantity;

2nd. It must be of good quality from a physical, hygienic and chemical standpoint;

3rd. Its development must be adequate, safe and economical.

4th. It must be maintained properly following its installation.

5th. It must be universally used.

The questions relating to quantity, quality and development are dependent upon preliminary study and the preparation of proper plans. The maintenance and use of the supply are, however, conditions which are subject to the control of the authorities in charge.

The benefit resulting from water supply installations may be measured by the improvement in the health of the community or by financial considerations. The improvement of health conditions is dependent primarily upon the quality of the water supply developed. If the supply is of good quality from physical, hygienic and chemical standpoints, is properly developed and is generally used, we may expect the maximum reduction in diseases resulting from water-borne infection. In proportion to the extent to which any of these features are deficient the improvement in health conditions will be lessened. It is frequently the case that a water supply of excellent sanitary quality but of objectionable physical or chemical quality is installed and on account of its unfavorable appearance is not used for drinking purposes. As a result, private wells continue to furnish water for this purpose and no marked improvement in health conditions results. Prejudice against public water supplies frequently contributes to prevent the general use of a supply entirely satisfactory. In such cases the maximum benefits are not realized. The method of development of a water supply of good quality may frequently determine the advantages to be derived, for instance, a ground water supply of a high degree of purity may deteriorate by storage in an uncovered pump well or reservoir. Algal growths may cause tastes and

odors to appear at certain seasons of the year which will contribute to make the water supply generally unpopular.

One of the principal advantages to be derived from a water supply, and one which is generally recognized, is the introduction of modern plumbing facilities in the home. This permits the abandonment of private wells, which may be dangerously contaminated, and the use of indoor sanitary equipment, which makes possible the removal of the insanitary privy.

From a financial aspect the introduction of a public water supply is to be considered a good investment. There results an actual saving to the individual, a general increase in property values, the provision of fire protection and an attraction to industries in search of a suitable location. The financial measurement of the advantages of a public water supply is determined largely by the quality, quantity, development and use of the supply. The consideration of the financial value of a water supply from the standpoint of its quality has been dealt with completely by Whipple in his treatise on the "Value of Pure Water." Assuming absolute purity as a standard of greatest value, he has shown, for instance, that unsatisfactory physical quality may result in a loss of from five to twenty dollars per million gallons of water pumped; unsatisfactory hygienic quality, fifty to one hundred dollars per million gallons; and objectionable chemical quality, ten to twenty dollars per million gallons. The mere provision of a water supply may, therefore, not result in a great financial advantage; it is also required that the quality be such as to bring the maximum benefit to the community.

Considering next the advantages of a sewerage system, a few brief words of explanation of what a sewerage system is may be of benefit. Sewerage systems are divided into three classes, according to their use. The sanitary sewer system is employed for the removal of house sewage and all objectionable liquid wastes. Storm sewers are used for the removal of surface drainage, while combined sewers are utilized for the removal of all classes of wastes and surface drainage. For the small village, especially where treatment of the sewage may be required, the sanitary sewer system is by far more preferable than the combined sewer system for the removal of sewage. Any sewer system, to furnish good results, must be of proper capacity, laid with proper grades and in general designed according to good engineering practice. Its construction must also be carefully supervised. After its installation it must be maintained in its most efficient condition. Of course, the sewer system will not furnish maximum benefit until it has become universally used. We may, therefore, state that the full advantage of a sewer system will be realized only when the following conditions have been met:

1st. It must be properly designed and constructed.
2nd. It must be properly maintained.
3rd. It must be universally used.

The first two factors are dependent upon preliminary study and the plans under which the system is built, but the use of the sewers is a matter which can be regulated by the authorities in charge.

The benefits resulting from the installation of a sewerage system may be measured according to the same standards as a public water supply improvement, namely, by the effect on the public health and from financial conditions.

It seems unnecessary to refer to the improvement in health conditions resulting from the installation of proper sewers. First of all, a public water supply cannot be fully enjoyed in the absence of a sewer system. The provision of a system of sewers may, therefore, contribute some of the benefits resulting from the public water supply development. With provision of sewers the abandonment of cesspools and privies is facilitated and general cleanliness of the community is encouraged. Drainage and drying of the soil also results, which has an important bearing upon the general health. It may be expected that, following the installation and use of a system of sewers, the death rate from typhoid fever will be reduced about 50 per cent. Records of results obtained in a certain town in England indicate a reduction in deaths from pulmonary tuberculosis of over 50 per cent., following the introduction of sewers.

From a financial aspect the installation of a sewerage system is highly beneficial. It results in an actual saving to the individual as it provides an ever-ready means of disposal of house sewage at a cost considerably less than would be demanded in the installation and maintenance of cesspools. Increased property values also result from improved sewerage, and it may be expected that individuals and manufacturers will be attracted to a well-sewered community and thus enhance its value. The degree to which the sewer system becomes a benefit is, however, dependent upon the extent of its use. Frequently it has been found that the citizens of a community have failed to appreciate the value of a sewer system and have neglected to properly utilize it. The result has been a continuance of the privy and cesspool nuisances and general insanitary conditions of the community. It is well to remember that following the installation of a sewer system its general use should be required by the municipal officers in authority.

Having reviewed the advantages to be derived from public water supplies and sewerage systems, a brief explanation of the method of obtaining these advantages may be of value. A popular desire for the improvements is, of course, necessary before the village authorities can hope to make the actual installations. However, before the expression of the electors is obtained it is important for the village authorities to become thoroughly informed as to the general method of development of the works and the cost of the same. When the council of a village has determined to take steps to install a public water supply or sewer system a competent engineer, experienced in this field of work, should be retained to make preliminary surveys, general plans and an estimate of cost for the improvements. In case of a water supply the preliminary survey should include a study of available sources and in this connection the considerations of quantity and quality enter. No source of supply should be determined upon until a complete test as to its quantity and quality has been made. In the case of a sewerage system the preliminary survey should include the general layout of a sewer system and location for outlet or treatment plant. After the preliminary survey has been completed general plans and an estimate of cost should be made and these submitted to the village council for adoption. Following their adoption by the council they should be submitted to the Board of Health for approval and after this approval is secured the village authorities should immediately take up the question of educating the people in the advantages to be derived from installing the improvements contemplated. In some cases this campaign of education may require the utmost effort on the part of the village authorities. After a favorable expression of the electors on a bond issue is secured the village should again call upon their engineer to prepare detail plans and specifications for the work. These should be submitted to the Board of

Health for approval and following such approval the contract for the work should be advertised and awarded according to law. The duty of the village authorities does not cease at this point and during the construction of the work a competent engineer should be retained to protect the interests of the village and see that plans are strictly adhered to. When the works have finally been installed according to the plans and specifications the village authorities must assume the duty of properly maintaining them. Too much emphasis cannot be placed upon the necessity for proper maintenance of water supply and sewerage improvements. In small villages the authorities are likely to become lax in this duty, especially if political considerations govern the selection of men employed in public service. The beneficial effects of public water supplies and sewerage systems are largely dependent upon the care with which they are managed and operated. Aside from the financial considerations the beneficial effect upon the public health may be impaired if works of this character are carelessly maintained and operated.

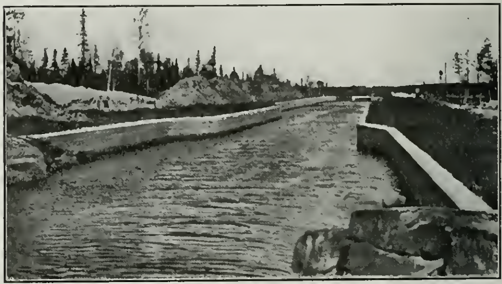
PIER CONSTRUCTION AT VICTORIA.

In connection with the construction, by the Department of Public Works of British Columbia, of several piers at Victoria, B.C., eighteen concrete cribs are being constructed. All of them, with the exception of two, are being built with the aid of a large, floating dry dock, recently leased by the contractors, Grant, Smith and Co. and McDonnell, from the Seattle Dry Dock and Construction Co. The dock, although not a new one, has a capacity of 8,000 tons. It is 325 ft. in length, with a 102-ft. beam, and towers 32 ft. 6 in. above the deck of the pontoon or scow. Its sides are 40 ft. in height.

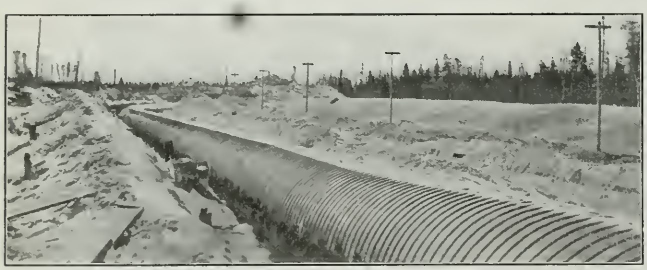
The dry dock was delivered to the contractors on May 28th, and will shortly proceed to Esquimalt, where the concrete cribs will be constructed and floated, one by one, to the dock site upon completion. These cribs will be 100 ft. in length, 39 ft. in width, and have a height of 39 ft. Each will weigh 3,500 tons, and two of them will be built simultaneously on the dry dock. The first two cribs are being constructed by the method first adopted, that of building them on marine ways and launching them with rollers. This method is being abandoned, however, for the remaining 16 cribs, it having been found uneconomical.

THE WAWAITEN FALLS AND SANDY FALLS HYDRO-ELECTRIC POWER PLANTS.

THE Northern Canada Power Company, Limited, operates two hydro-electric plants on the Mattagami River, namely, Wawaiten Falls, twelve miles southwest, and Sandy Falls, six miles northwest from the town of Timmins, Ontario. It is from these two plants that the gold mines of Porcupine derive their power. The following data concerning them are from the recent report of the Timiskaming and Northern Ontario Railway Commission, prepared by Mr. A. A. Cole, its mining engineer.



Headgate and Canal Leading to 12-ft. Iron Pipe Line, Wawaiten Falls.



Wood Stave Pipe, 1,550 ft. Long, 9 ft. Diameter, at Wawaiten Falls.

Wawaiten Falls plant is located in the township of Thornloe at the foot of Lake Kenogamisee. A concrete dam 1,000 feet long at this point, diverts the water into a 1,200-foot canal. From the intake at the foot of the canal, water is carried by 1,500 feet of 12-foot iron pipe to a 40-foot diameter surge tank on top of the hill overlooking the power house. Two 8-foot iron pipes, 1,300 feet long, lead from this surge tank down the side of hill direct to the wheels in the power house.

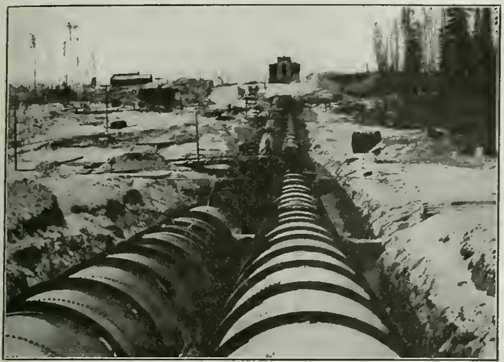
The power house is of reinforced concrete and contains two 3,300 horse-power Morgan-Smith water-wheels operating under a head of 125 feet, direct connected to two 2,500 k.v.a., 3-phase, 12,000-volt Canadian Westinghouse alternators; two 70 kilowatt exciter sets driven by independent water-wheels and Westinghouse switching and switchboard apparatus. During the summer and autumn of 1913, the power company installed 1,500 feet of 9-foot wood stave pipe line from the intake of canal to surge tank, duplicating the

View of Wawaiten Falls Dam from Lake Kenogamisee.

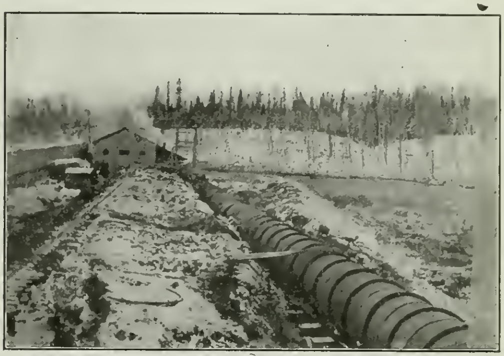
present 12-foot iron pipe. Material for this line is 2-inch Oregon fir, and was installed under the supervision of the Pacific Coast Pipe Company's engineer.

Sandy Falls plant is located in the township of Mountjoy. A timber dam of approximately 1,500 feet in length diverts the water into a wooden flume 14 feet by 16 feet by 700 feet long. Water from the flume is taken direct to the wheels in the power house by means of short lengths of 10-foot pipe. The power house is of timber construction covered with asbestos and corrugated iron, and contains two 1,200 horse-power Morgan-Smith wheels operating under a head of 33 feet, direct connected to two 950 k.v.a., 3-phase, 12,000-volt, Canadian Westinghouse alternators with exciters on the same shaft. Switching and switchboard apparatus is of Westinghouse manufacture. During the summer of 1913, the power company commenced extensive improvements at this plant. The timber dam is being replaced with a concrete dam and wooden flume with steel pipes. It is expected this work will be completed during the summer of 1914. The transmission lines consist of two complete circuits on a single pole line from each plant, and are so built and connected that plants are operated in parallel. Power is supplied to consumers at approximately 12,000 volts, 3-phase, 25-cycle.

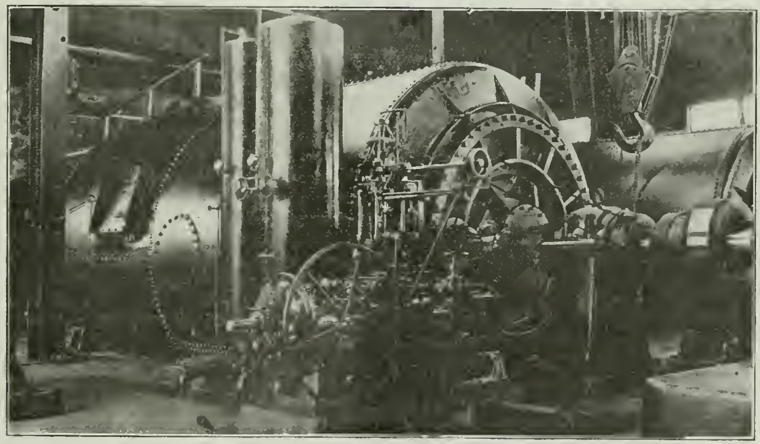
The power company has 35 miles of main and branch transmission lines now operating in the district.



Two 8-ft. Iron Pipes, 1,300 ft. Long, from Surge Tank (in distance) to Power House at Wawaiten Falls.



Sandy Falls Power Development—New Steel Pipe Leading to Power House.



Two Morgan-Smith 3,300 h.p. Water-wheels with Lombard Governors, Wawaiten Falls, Ont.

On Thursday, July 9th, the Westinghouse strike at East Pittsburgh was called off by the workmen, a large number of them reporting for work on the following day, and the works since the beginning of last week have been running full time.

On July 4, a section of the Port Arthur C.N.R. steel dock about 70 feet square and containing about 3,120 tons of steel rails, collapsed. The dock is practically new, having been built only three years ago.

As a result of the decision of the railway commissioners, made in Calgary on June 22, it is expected that the coal mines near Lethbridge, Alta., will go into operation on July 1. The understanding reached with the railways is that coal sent forward for storage and not used until after September 1 will get the new freight rate. The old rate will be paid up to September 1, and all the coal in bins on that date will be given a rebate to reduce the rate to that figure.

APPLIED GEOLOGY IN MUNICIPAL ENGINEERING.*

By Herbert Lapworth, D.Sc., M.Inst.C.E.

FEW municipal engineers of to-day can fail, after much experience, to realize the importance of practical geology in the construction of their works. The success of underground water supplies, whether attained by knowledge, trial and error, or by a stroke of luck, is admittedly dependent in each case upon the local geology. In works of sewerage, again, the cost may be largely influenced by the nature of the geological materials met with in the trenches and tunnels, producing as they may do difficulties and expense in excavation, timbering, dealing with ground-water, and modification in the design and construction of the permanent work. The same general principles apply to all deep excavations or foundations that may be carried out by the municipal engineer, whether in the construction of new roads with deep cuttings; sea, river, and retaining walls; bridges, reservoirs, sewage tanks, or large buildings. The geology of building stones, road-metals, and similar materials, though in a lesser degree, is of importance in all those branches of municipal work in which they are constantly employed.

One of the most striking factors that has forced applied geology upon the attention of the engineer has been the number of disputes which have arisen between contractors and municipal authorities concerned almost solely with the "nature of the ground" encountered during construction of public works. A few of these cases have been taken to the courts, some to arbitration, while others have been privately settled. In most instances the cause of the dispute has been due to some misunderstanding as to the "nature of the ground," or, in other words, the geology of the excavations; and almost invariably the ultimate result has been costly.

Frequently this kind of trouble has been the result of providing intending contractors with inadequate or misleading descriptions of the strata, obtained from trial holes or borings. Another cause has been the enforcing under the contract of a type of construction unsuited to the kind of ground unexpectedly encountered in the trenches or foundations.

Quite outside the question of legal disputes, however, serious difficulties have arisen, and heavy expense has been incurred by locating works in bad ground, either through lack of previous geological investigations or by wrong deductions from haphazard exploration, when such troubles might have been avoided in the original location or largely anticipated by investigation with practical geological knowledge.

It is a remarkable fact that this branch of engineering, common as it is to all classes of the profession, and on which so much frequently depends, is so strangely ignored in our own engineering literature, and until recently so little considered in the scientific training of civil engineers. Thus we find in our engineering text-books the most minute mathematical investigations of structures, more or less without relation to the varying geological materials on or in which they may be placed.

As a minor example, retaining walls, the dimensions of which, other things being equal, depend entirely upon the geology, water-bearing nature, and dip of the materials to be supported, are subjected to detailed mathematical analysis which may, in the drawing office, be slavishly applied to practice by arithmetical and graphical calculations, without any knowledge of the ground in which the walls are to be built.

To a limited extent the design of tunnel and sewer sections, for example, in "good" and "bad" ground, are considered in text-books; but no account is given of the many types of material met with underground, under varying conditions; nor of the principles of the occurrence of underground water, the great variation in cost, and the difficulties of construction under different geological conditions. Under "earthwork" we find the usual tables of slopes, prismoidal formulæ, and the like, but practically nothing on the highly important subject of "slips," or treatment of soft, unstable, or "bad" ground.

It may be argued, and rightly, that these are matters of actual practice and experience; but this does not excuse the failure of these treatises to impress the student with the great variation in cost and difficulties of engineering construction in different deposits, and the fact that efficiency and economy in construction might be as much the result of geological knowledge and investigation as of skill and experience in calculation and design. In some degree this void in the engineering text-books is due to the extreme complexity and variation in the physical properties of the geological deposits, which render them incapable of mathematical analysis.

Another inconsistency is sometimes to be seen in the letting of large contracts, where we may have items in the schedule of quantities amounting to only a few shillings, yet the contractor may be wholly ignorant of the character of the ground in which the works are to be constructed, and may in consequence under-estimate by several thousand pounds the cost of excavation.

The causes which have contributed to the scant consideration of practical geology among engineers are not easy to determine. Probably the chief of these is the fact that, whatever geological difficulties do arise during construction, it is always possible to complete engineering works, whether economically or not, without geological knowledge, and the engineer is not likely to be blamed by his employers for what turns up unexpectedly below ground.

Secondly, there is a pessimism among certain engineers, some of whom, though they may be experienced in excavation work, have little time for geology, and see only a comparatively heterogeneous mass of deposits underground in no cort of order, and to be classified broadly into two types—"rock" and "muck." There is also the optimist, who expects the geologist by surface indications alone to prophesy precisely what will be met with in almost every yard of his proposed trench, and in consequence loses faith in the accuracy and practical application of the science.

Thirdly, we have scant consideration of the subject in the engineering and geological text-books. The former have already been discussed. The latter, while containing all the necessary elements for the study of the subject, rarely present the applied or practical side of the science, except on the very broadest lines, and include matter that is unnecessary to learn, and which has rarely any direct bearing upon engineering questions.

In the writer's opinion, every civil engineer should be familiar first with the elements of geology, i.e., the principles of stratification, and formation of rocks and deposits, and the various structures occurring in them as the result of formation, change, weathering, or earth movements. He should be able to recognize and describe correctly all the common solid rocks and unconsolidated

*From a paper read at the 41st Annual Conference of the Institution of Municipal and County Engineers, Cheltenham, June 24th-27th, 1914.

deposits. He ought also to understand a geological map as he does a working drawing, and be able to plot approximate geological sections from it, as well as accurate geological records from borings, trial-holes, trenches, and tunnels. A training in petrology is desirable for the road engineer; but expert knowledge in this branch of geology usually requires more time than the professional engineer can afford. A thoroughly practical geological training, however, cannot be acquired without considerable experience in the field.

Of equal importance is the subject of hydro-geology. This includes the principles of the occurrence of underground water in different geological deposits, the laws of flow through porous and permeable materials, underground water-levels and their fluctuations. The mathematical side of this subject has been considered in great detail by foreign scientists and engineers; but so far the quantitative results have been of little direct application to practice, owing to the extreme complexity of underground conditions. Nevertheless, the principles arrived at are of great value in clearing one's ideas, assisting one to anticipate or prophesy, and to deal more rationally with underground-water problems where a certain amount of local information has already been secured. The value of this science is not only found in questions of water-supply, but in the excavation of trenches, cuttings, deep foundations, tunnels, drainage, and the like.

It would be impossible in a paper of this kind to cover the whole of that region in municipal engineering on which practical geology has a direct bearing. The following are merely a few selected instances commonly occurring in practice.

Preliminary Geological Investigations on Important Works.—In the majority of important public works it is desirable to ascertain by means of trial holes or borings the nature of the ground in which the works are to be constructed. The object of these investigations may be to determine first, the necessary dimensions of the permanent work and its approximate cost; secondly, the ground-water levels; thirdly, whether any saving may be affected by a change in location, if practicable; and lastly, to enable contractors to make a fair tender for the cost of construction. As regards the latter, it has given rise to discussion among engineers, whether data obtained from trial holes and borings should be shown to tendering contractors, because of the possibility of future claims or litigation. Information of this kind, however, allows a contractor to put in a fairer price, and avoids the necessity of his protecting himself, as he often does, by increased prices for unknown ground. Without such knowledge, a contractor's tender must usually be either unfair to the municipal body or the contractor himself; but there are pitfalls, of course, although the more practical geological knowledge there is brought to bear on the investigation, the less will be the risk.

As regards the selection of sites for boring, etc., it is essential that the number of holes should be sufficient to give reliable information, and the strata must be correctly described. Each hole should be sunk to the full contemplated depth of the excavation, and located on the centre-line, or within the limits of, and not outside, the work itself.

An interesting example of the result of sinking trial holes clear of the work occurred recently in this country in connection with a tunnel sewer. The trial holes, in order to save expense, were sunk in a railway cutting parallel to the sewer. These proved the ground to consist entirely of sandstone and conglomerate, whereas at least half the length of the tunnel was found to be in marl, the discrepancy being due to the cross dip of the strata. In the sandstone and conglomerate the tunnel was driven without timber, while in the marls close-timbering was required throughout, owing to falls from the sides and roof. An action was brought by the contractor against the public authority on the basis that misleading information had been supplied to him.

In the solid rocks the selection of the sites for trial holes, etc., can often be much assisted by a knowledge of the surface geology. This is especially applicable to tunnel work and the like; but the majority of municipal works are founded close to the surface, and the nature of the ground is dependent more on the character and depth of the soils, sub-soils, and surface deposits of the districts. As the detailed structure and arrangement of these surface deposits cannot be foretold with any accuracy from surface indications, trial holes or borings are essential.

Water Supply.—It is perhaps in questions of water supply, and especially in schemes from underground sources, that a sound knowledge of geology and hydro-geology is essential. The selection of a site for a well or boring, which will yield a satisfactory amount of pure water requires intimate acquaintance with the local geology, the order, arrangement and structure and water-bearing characters of its various strata, both as regards its solid rocks and superficial deposits. Familiarity with hydro-geological principles will also assist the investigator in analyzing more rationally from data in local wells and springs the existing underground water resources of the district, and in considering questions of possible pollution from farms, fields, cess pits, cemeteries, and polluted streams. Similar principles apply largely to water supplies from springs.

Geological considerations are also highly important in the selection of sites for impounding and service reservoirs, dams, and embankments, and in the location and construction of lines of aqueduct, pipes, and tunnels; but these are matters, perhaps, more usually in the domain of the consultant, dealing with large schemes, than in the routine work of municipal engineers.

Lines of Sewers and Pipes.—In the construction of lines and sewers we find many questions arising, where applied geology may be of use in location, design, and construction. The most serious difficulties are generally encountered in the unconsolidated deposits of alluvial, glacial, and other recent origin. The beds of clay, silt, mud, running sand and peat, which so frequently occur in these formations, are usually capable of supporting only relatively low pressures, and require great skill and experience in the treatment of cuttings or excavations, being especially liable to slips, and to act as a semi-liquid when their existing stability is disturbed by any excavation within their mass. Occurring as they do in the low-lying areas in valley bottoms, estuaries, and mud flats, they are liable to be saturated with ground-water, which further reduces their stability, and adds greatly to the difficulties of engineering construction.

In addition to the obviously water-logged ground formed of these deposits in low-lying areas, many lines of pipes and sewers may be constructed in water-bearing rocks, and deposits below the saturation level. The opening out of a deep trench in porous or permeable material below the saturation level has the effect of draining the measures on both sides of the trench, and producing a lowering of the water-levels in the vicinity. This may often give rise to claims for damage to local wells and springs. Any trench excavated below river-level, in a valley bottom and in permeable strata, will tend to collect a large volume of water; and similarly where the satura-

tion level rises from the valley bottom more or less parallel to the ground surface, a deep trench, although distant from the river, may require heavy pumping during construction. In all permeable surface deposits and permeable strata, such as chalk, sandstone, sands, and heavily fissured rocks, in which trenches are to be excavated, it may be often worth while to determine the underground water-levels in local wells, in order to see whether it is possible to fix the levels of the permanent work above them. Local wells have not infrequently been drained dry during the construction of a deep sewer, and sometimes permanently, so that it has been necessary to deepen them in order to restore their water supplies.

In considerations of this kind, hydro-geology has shown that the saturation level is subject to seasonal fluctuations; hence it may happen that a trench excavated in dry ground above the saturation level during one part of the year may be flooded during the winter and early spring seasons when the ground-water is high.

Heavy pumping, and consequent lowering of the saturation level in certain sands, peat-bogs, and marshes, may also seriously affect the foundations of adjacent buildings, producing cracks and settlement. Cases are on record where the saturation level has been lowered several feet by pumping, and accompanied at a distance of 200 feet by a settlement in the building of several inches.

In hilly districts, sewers and lines of pipes may require to be constructed in steep sidelong ground and scree slopes. Here there is a strong tendency for the surface material to slip into the trench, and great pressures may be brought to bear upon the timbering, and even upon the permanent work, which may be forced downhill and fracture. Such catastrophes have occurred both on lines of cast iron pipes and brick culverts in this country.

In certain types of ground again, such as those formed of steeply dipping shales or clay masses, or surface materials upon a highly inclined rock surface, slips are liable to occur, and even the permanent work may require to be strengthened.

Another curious phenomenon is occasionally found in deep trenches wholly in clay deposits, which may appear to be perfectly consolidated and firm during excavation. The weight of the material on both sides of the trench may be sufficient to cause the plastic material to flow, with the result that the timbering must be crushed in and collapse, accompanied by an uplift of the bottom of the trench, and of the permanent work. The writer has known of a length of over 100 yards of culvert invert, and side walls destroyed in this way. In some of the glacial clay deposits of Lancashire the trench bottoms have been observed to rise between the operations of trimming the trench bottom and bedding the pipes.

In ground of soft clays, mud, silt, running sand or peat, the difficulties of construction are, of course, at their worst. Special precautions must then be taken from the outset in timbering, strengthening the section of the permanent work, draining, and so dealing with the foundations below formation level, as to enable the ground to support the weight of the overlying structure.

The subject is too vast, however, to discuss here; but it may be taken for granted that in questions of this kind, the engineer armed with a sound knowledge of the local underground geology and its relation to the subsiding surface is likely to be more efficient, not only in dealing with lines of pipes and sewers, but with reservoirs, filters, bacteria beds, and other works.

Roads and Road Metals.—In the construction of new roads in the colonies or other foreign countries, practical geology may be a very important factor in location, where the choice of a route may be guided by the geology of the district to be traversed. Thus areas liable to slips, or former of very soft or very hard material, or requiring heavy retaining walls, may sometimes be avoided by deviation. In this country, however, the routes of the few new roads that are now being, or likely to be, constructed, are more or less fixed within rigid limits. Still, even here, practical geology and hydro-geology, when combined with engineering experience, are valuable aids in the excavation and drainage both of the cuttings and the road-bed itself.

As regards the materials for road metals, a sound knowledge of the occurrence and petrology of road stones is decidedly useful. The early experimental and scientific work of Lovegrove, Howe, Flett and others was a promising beginning in the scientific study of road metals. The introduction of tar and bituminous compounds, the tests of different materials in actual use on the road marked further stages. But road engineers are still finding difficulty in arriving at standards of value in road materials, and much practical and scientific work seems still to be necessary, both from the engineering and geological aspects. The modern road must necessarily be a complicated study, containing as it does problems in physics, chemistry, and geology. Perhaps with the establishment of courses in highway engineering at the universities, we may stimulate scientific research in this direction, and in conjunction with the practical results and experiments of road engineers, evolve a new technology, for which there seems to be a considerable need.

SUDBURY AND COPPER CLIFF SUBURBAN ELECTRIC RAILWAY.

Announcements have appeared from time to time in these columns respecting the organization and construction of the Sudbury and Copper Cliffe Suburban Electric Railway. Latest advices contain the following information relative to it:—

The provisional directors of the road are Messrs. L. Laforest, Bell, Cochrane, Morin, Mackey, McCrea and Norton. Mr. C. D. Norton is engineer for the company.

The only route upon which any survey work has been done up to the present is the Copper Cliff route, 5.1 mi. in length, with a grade of 4 per cent. The curvature is as follows: one 50-ft. radius, one 200-ft. radius, one 20°, two 15°, five 10° and a couple of curves of about 1½° or 2°.

There will be one 3-span trestle bridge, two single-span trestles and two small deck culverts. Corrugated iron pipe will be used for culvert work.

On the Copper Cliff route two miles have already been graded. The company is employing day labor and propose laying track by the same method. Some station work has, however, been let by contract. An 80-lb. rail is being used. On the 0.43 mi. of track in the town of Sudbury a permanent pavement is about to be laid. The ties will be laid on a 6-in. concrete base and filled in with concrete between. The Warren Bituminous Paving Co. is doing this work.

With respect to rolling stock, it is proposed to acquire two interurban cars and one city passenger car, although the entire question of rolling stock has not as yet been definitely decided upon. There will, however, be a combination freight and express car and a combination work and tank car and snowplow.

Mr. Norton states that it is proposed to use D.C. current at 200 volts on the Copper Cliff route outside the town of Sudbury and 600 volts D.C. within the town limits.

WOOD PRESERVATION.

A PAPER recently appeared in the Journal of the Royal Society of Arts, written by Mr. A. J. Wallis-Taylor and descriptive of modern processes for the preservation of wood. It is stated that wood should be seasoned for at least 6 to 12 months before treatment. (1) Kyanizing consists in steeping timber in a 1 per cent. solution of mercury chloride for 7 to 11 days. (2) Burnettizing comprises preliminary steaming, followed by impregnation in a 2½ to 2 per cent. solution of zinc chloride under a pressure of 7 to 8 atmospheres. In the zinc-tannin or Wellhouse process, treatment in a partial vacuum follows the preliminary steaming, a small percentage of glue is added to the zinc chloride, and after impregnation for 2½ to 6 hours at 100 to 125 pounds pressure per square inch, the timber receives a final treatment with a 0.5 per cent. solution of tannin under the same pressure for two hours. (3) Creosoting usually involves steaming of the dried timber, heating under reduced pressure, and treatment with creosote oil under a pressure of 100 to 180 pounds per square inch. The amount of creosote absorbed by the timber varies from 7 to 20 pounds per cubic foot, and the temperature of the treatment should be between 100° and 130° C. In the Curtis-Isaacs process, the timber and creosote are heated to above the boiling-point of the sap at ordinary pressure in a retort having vents open to the air; the vents are then closed and the creosote is forced into the wood under pressure. The Rueping process consists in forcing, first, compressed air at a pressure of 80 to 100 pounds per square inch into the pores of the wood, and then at a higher pressure creosote oil, without relieving the air pressure. In the Lowry process treatment with creosote oil at 77° to 82° C. under a pressure of 180 pounds per square inch is followed by draining and a rapid vacuum treatment. In the zinc-creosote or Rutger process an emulsion of ½ pound of "dry zinc" and 1.5 to 4 pounds of creosote oil per cubic foot of timber is used; the emulsion being continuously agitated (e.g., by a centrifugal pump). The Hasselmann process uses a solution containing copper, aluminum, and potassium sulphates, heated 118° to 126° C. under a pressure of 35 pounds per square inch. In the creo-resinate process (especially suitable for wood paving blocks) air at 121° C., under a pressure of about 100 pounds per square inch, is substituted for steam; the antiseptic agent consists of 50 parts of creosote oil, 48 of resin, and 2 of formaldehyde, and impregnation is followed by a treatment with lime water at 100° C. under 150 pounds pressure. The Guissani process uses a mixture of anthracene and pitch heated to 140° C., in which wood is submerged until it is free from moisture and sap, after which it is successively treated with cold, heavy tar oil, and cold zinc chloride solution. In the saccharine solution or Powellizing process, suitable for the treatment of green wood, a solution consisting mainly of sugar, with a small percentage of arsenic, is used. The vulcanizing or Haskinizing process consists in roasting wood, which has been previously dried by steaming, to a temperature high enough to coagulate its dried albumins (71° to 94° C.), and to resolve some of the fibre and sap with the production of wood creosote. In addition to the use of definite antiseptics and of a large number of metallic salts for wood preservation, mineral oils, preferably mixed with asphaltum can be used to fill up the open wood cells, thus protecting the timber from the action of heat moisture, and air. By the zinc chloride process the life of wood is more than doubled; creosoted wood lasts 25 to 50 per cent. longer than wood treated with zinc chloride, but costs three or four times as much. The amount of preservative injected into one cubic foot of various classes of timber ranges from about 3 pounds of mercury chloride in the case of hard woods to about 6 pounds for moderately hard woods and 10 pounds for soft woods, the corresponding amounts of creosote oil being 3, 10, and 20 pounds respectively. The average costs of preserving timber with zinc chloride, creosote oil, and mercury chloride are approximately 2.5 cents, 10 cents, and 16 cents per cubic foot respectively.

CIVIC WORK IN HAMILTON, 1913.

In the annual report for 1913 of Mr. A. F. Macallum, City Engineer of Hamilton, the population of the city is given as 100,808; and its acreage, 6,450. During 1913 a new 4-ft. intake into Lake Ontario, 2,120 ft. in length, was laid., the new pumping station at Burlington Beach was completed, and a new high-level pumping station of 4,000,000 gal. capacity also erected. A standpipe, 100 ft. in height, with a capacity of 80,000 gal., was erected on the mountain and connected by a 12-in main to the high-level pumping station.

The large trunk sewer on Ottawa Street and many small sewers were finished during the year. Construction

Asphalt Plant at Gage Avenue, Hamilton; 1,500 Yards Capacity.

work in connection with the West End sewage disposal works (for illustrated description, see *The Canadian Engineer*, Jan. 22nd, 1914), progressed very favorably. The grit chambers and sludge tanks were finished and the excavation and piling done for the six Imhoff tanks, three of which were partially completed before the close of the season.

In connection with pavement work, a new asphalt plant with a capacity of 1,500 yds. per day was built in the east end of the city. When it had been completed, the city operated both asphalt plants, with the result that more asphalt pavements were laid in Hamilton in 1913 than in any previous year. In addition to sheet asphalt, a considerable amount of creosoted wood block and asphaltic concrete pavements were laid. The total yardage of various kinds of pavement laid during the year was computed in our issue of April 16th to be 279,-497 square yards.

The Province of Ontario has produced 200,000,000 ounces of silver since the Cobalt deposits were discovered in 1903.

THE TRAINING OF THE HIGHWAY ENGINEER OF THE FUTURE.*

By H. Percy Boulnois, M.Inst.C.E.

THERE can be no doubt that the introduction of self-propelled traffic by means of the internal combustion engine has entirely changed the problem as to the weights and speeds of the traffic which the road of the future may be called upon to bear. With horse-drawn traffic these weights and speeds were limited within almost rigid limits, but with modern traffic these limits are removed and no one can tell as to what weights, and at what speed, the traffic of the future may develop. It is true that legislation may, from time to time, impose restrictions on the traffic, as it has frequently done in the past, but the clamor of commercial needs and the popular outcry for increased means of transport will very soon break down any such artificial barriers to progress, and the highway engineer of the future will have to provide for these inevitable changes which are certain to take place.

The past evolution of our railways is one instance of the change that arose immediately mechanical methods of transport were introduced. The lightly constructed railway of the past has had to give way to a strongly built permanent way that will carry the enormously increased weights of the locomotives and carriages which are now imposed upon it, and the permanent-way engineer has had, from time to time, to strengthen and improve his roadway in order to meet the ever-increasing demands made on him by the locomotive and rolling stock departments. It is by no means inconceivable that the highway engineer of the future will shortly be called upon to make similar improvements in his roads, and he will suffer from the great disadvantage of not having that control over the user of his roads which the railway engineer enjoys.

But apart from this, we are already face to face with the fact that road construction is inevitably altering in its character. Where formerly there was but one form of construction for the ordinary road, viz., that which was known as "waterbound macadam," there are now already a large number of different methods of construction, for all of which special advantages are claimed. It is evident that the "road question" has entered a scientific field never before contemplated, and that something more will be required of the highway engineer of the future than the mere rule-of-thumb experience of the past. The question consequently arises as to whether there is a necessity for specializing in this direction, or whether the ordinary training of a civil engineer is sufficient for the purpose. The question is, therefore, is there a demand for the special profession of the highway engineer, and, if so, in what manner should he be trained?

That there is already a demand for the special profession of highway engineering is very evident, but the manner in which the highway engineer of the future should be trained is not so easily answered.

It is difficult to say exactly what this special training should be. In the United States an endeavor has been made to meet this question by giving a special course of training in highway engineering at the Columbia University in the City of New York, which might form the basis on which some such special training could be instituted in other technical universities and colleges.

It may, of course, be argued that technical instruction and laboratory experiments will not make roads, but I do not think it can be denied that the young man who is equipped with a thorough scientific and theoretical knowledge of his subject should be better able to cope with the present-day traffic problems than one who is not so equipped. The great Chinese philosopher Confucius, about 2,000 years ago, wrote:—

"The craftsman who desires to execute his work to perfection must first see that his tools are sharp."

This technical training must, however, be followed by practical experience, and there appears to be no better way of acquiring this experience than that of an articled pupilage under an engineer or surveyor who is responsible for the roads in his district.

If the road of the future will demand more science for its well-being, it is only right that science should demand better pay for its work. The specialist should always be able to secure better remuneration than the ordinary practitioner, and this should hold good for the highway engineer of the future.

I have endeavored to show in this short paper that:

(1) A new profession, viz., that of the highway engineer, is on the eve of commencing.

(2) He should receive a special training for the purpose of this new profession; and

(3) That his services require adequate remuneration.

*Abstract from paper read before the Institution of Municipal and County Engineers, of Great Britain, June 24-27, 1914.

UNIFORMITY IN BOILER INSPECTION.

A notable improvement that was arranged recently at a conference of boiler inspectors of the different provinces of Canada is the adoption of a uniform set of regulations for the entire Dominion. Doubtless the boiler manufacturers interested in Canadian business will appreciate the efforts that are being extended in an endeavor to bring the provinces into uniformity in this respect, as it will enable inspection in one province to be accepted in any other.

At the present time Manitoba, New Brunswick and Nova Scotia have no regulations, although legislation requiring them has been passed.

Mr. D. M. Metcalfe, chief boiler inspector for Ontario, is chairman of the conference.

RAILWAY ACCIDENTS IN CANADA.

During 1913, there were, according to the report of the Board of Railway Commissioners for Canada, 2,547 accidents on Canadian railways, involving the death of 643 persons, of whom 21 were passengers, 303 employees and 319 others. Of the 2,231 injured 410 were passengers, 1,603 employees and 21 others. With respect to accidents the report states:—

"Inquiries into derailments have brought out the fact that track conditions are largely responsible for such accidents. This is mostly accounted for by the fact that railway companies have not, on the whole, increased the efficiency of their roadbeds proportionately with the increases in the weight of their rolling stock." As to collisions it is said: "At first thought it would seem almost imperative that railway companies should be required to adopt, without undue delay, some form of positive block system on all lines. But we must not lose sight of the very important fact that the great majority of such accidents result from the non-observance of operating rules."

On June 26, the new municipal dock at Hull, Eng., was formally opened by their majesties, King George and Queen Mary. The dock has a frontage of one mile along the Humber, and embraces a water area of over 52 acres. Large new warehouses and 40 miles of railroad sidings have also been provided, together with special facilities for the shipment of coal. The total cost of construction exceeds $12,500,000.

HYDRO-ELECTRIC PLANT AT PANAMA

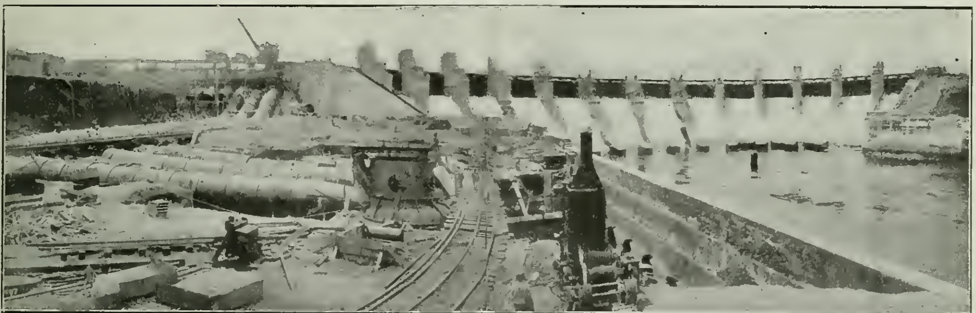
PROPOSED SUPPLY OF 12,000 KW. UNDER AVERAGE HEAD OF 75 FEET, TO BE DEVELOPED AT GATUN SPILLWAY FOR THE PERMANENT OPERATION OF THE CANAL.

Of particular interest in connection with the construction of the Panama Canal is the part which hydro-electric power is to play in its permanent operation. The supply of electrical energy for both lighting and power purposes on the canal is to be derived from a hydro-electric plant which is being installed at the Gatun spillway dam. It will utilize the surplus water of Gatun Lake, which is sufficient to supply 12,000 kw., of which 6,000 kw. will be developed by the plant at present under construction. The power will be used for lighting the canal, operating the gates and locking machinery, towing locomotives, and the general operation of machine shops, dry docks, waterworks and coal-handling plants at both ends of the canal. In conjunction with it there is a 4,500-kw. electrical supply, steam generated, at Miraflores, erected a few years ago to supply power for construction work. This will be used as an auxiliary to insure continuous service in case of accidents. The full utilization of the power available at the Gatun spillway, i.e., the entire 12,000 kw., will be brought into play with the proposed electrification of the Panama Railroad.

The head works of the development consist of reinforced concrete passages 12 ft. in width, fitted with wrought iron racks 29 ft. 7 in. high, to intercept floating debris from the surface of the lake. Through these passages water is admitted into the pipe lines by three head gates 10½ ft. in diameter. These cuts are of cast iron and watertightness is insured by bronze-capped seats. The available head from Gatun Lake to mean tide level of the Pacific varies between 79 ft. and 91 ft. representing extremely dry and flood seasons respectively. The plant is designed to develop full capacity under an effective head of 75 ft.

Intake Gates.—Each gate is equipped with two steel stems fitted with bronze nuts working in roller thrust bearings, and the nuts are fitted with steel bevel gears arranged to be operated by a 15-h.p., 220-volt, alternating current motor with a speed of 750 r.p.m. The motor is placed between the stems and has shaft-extensions on each side carrying two bevel pinions arranged to engage the gears on the stem nuts. The stands which carry these nuts are equipped with hand operating mechanisms, arranged to be disconnected when the gate is operated electrically.

The gates are equipped with automatic control devices, consisting of a limit switch geared to one of the gate stems and a float switch actuated by the water in the pipe. The gate-motor switch is closed at the power house, the gate being closed and the pipe line empty. When the gate has opened a distance which would fill the pipe line in about five minutes, the limit switch opens the circuit and stops the motor. When the pipe line is filled and the water rises in the 36-in. vent just below the gate, it actuates a float switch and again closes the motor circuit, thereby causing the gate to be opened fully, when the limit switch again operates to prevent over-travel. The gate is closed by reversing the main switch at the power house, causing the motor to operate, the limit switch stopping the motor when the gate has reached its closed position. An auxiliary hand-operated (2 men) mechanism is also installed for operating the gates.



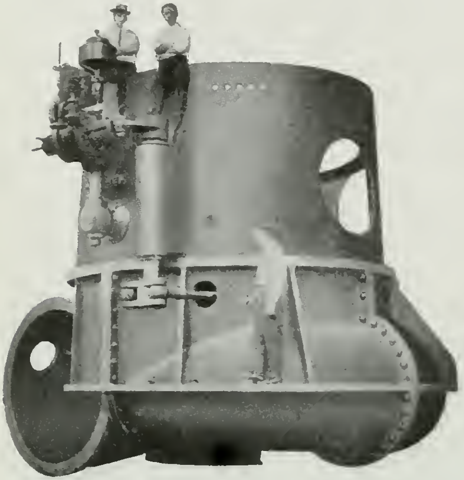
View of Gatun Hydro-electric Installation, Showing Pipe Lines, Turbines and Ogee Spillway Dam.

Pipe lines 10.5 ft. in diameter and 420 ft. long lead from the gates to the turbines to which they are attached by 90-deg. bends of 70-ft. radius. Each of the pipe lines is arranged for attaching a Pitot tube, while its unit is in service. The pipes are of ⅜-in. plate, courses 8 ft. long and three sheets around the circumference. Each course has a centre ring ⅜ x 3-in. Z-bar. The pipes are covered with reinforced concrete as rust protection. Each pipe has two 6-in. saddle-nozzle connections located 45° on each side of the vertical centre line of pipe. From these connections there are two Pitot-tube guide supports placed across the pipe at right angles to each other. These are bolted in the pipes and, while intended to be permanent, can be removed readily if desired.

Each 6-in. outlet on the pipe is closed by a gate valve with tongued and grooved flanges which match the base on the Pitot tube apparatus. Each Pitot tube is arranged to measure both the static and velocity heads at practically

the same point in the pipe, and readings are obtained by means of "U" tubes containing a colored liquid having a specific gravity of about 1.25. Carbon tetrachloride, thinned with gasoline to the proper specific gravity and colored red, is usually used for this purpose.

One end of each "U" tube is connected to the static and the other to the velocity side of the Pitot tube; the difference in height of the colored liquid columns is read, from which the velocity of flow in the pipe is calculated.



Pelton-Francis Turbine, 3,600 h.p.

The principal buildings connected with the actual operation of the canal are the hydro-electric station at Gatun spillway; the gate control house at the spillway; the four substations of the transmission system at Gatun, Miraflores, Cristobal and Balboa; and the three lock control houses. All these structures are designed along simple lines in harmony with the unbroken surfaces of concrete of the adjacent engineering works.

Generating Station.—The hydro-electric station measures 61 ft. by 137 ft. and has an extreme height of 74 ft. The building is designed on the unit principle, to admit of future extension, and consists of a single room open to the roof, exposing the trusses upon which are laid reinforced concrete roof slabs, which, in turn, receive red Spanish tiles. The walls are of poured concrete, 30 in. thick to the level of the crane rails, near the cornice. The exterior overhang of the main roof is 13 ft. 2 in. and that of the monitor roof 4 ft. 8 in., the exceedingly large projections having been generally adopted for all the permanent buildings in the Zone as a shelter from tropical rains, as well as from the heat of the sun.

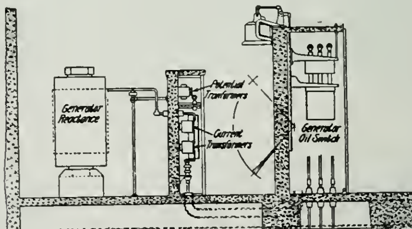
Beyond the general use of tiles for flooring, and an interior white-enamelled brick wainscot 14 ft. high, to relieve the coarseness of the walls, there is no difference in the finish of the concrete surfaces within and without. The dead surfaces of the concrete or stuccoed walls, which will probably be improved when weathered, are further relieved on the exterior by the red tile roofs. The principal ornamentation is on the under-side of the broad projecting cornice, which is broken up into panelled coffers. A number of these contain light outlets that cast light down on the walls and throw the structure into strong relief at night.

The interior has four principal elevations, namely, a pit for the three 2,500-kw. hydro-electric turbines, a main floor, and two galleries. The turbine pit, with an area of over 2,100 sq. ft., is located 6 ft. below the level of the main floor, and is reached by iron stairways descending alongside the turbines. From the pit other stairs lead down to the store room on the north side, and to the air-compressor and oil-pump compartments at the ends. The pit is lined with white-enamelled brick, and the 14-ft. wainscot extends from the main floor up to the first gallery elevation on the south wall of the pit.

The main floor is divided into two parts, one being devoted to the use of the electrical equipment, and the other forming an uninterrupted passage on the longitudinal axis of the building, terminating with two large entrance doors at either end. Easy access to railway wagons is afforded by means of a track which enters this floor through the northwest door, thus giving every facility for handling heavy machinery by the 30-ton electric crane running the length of the building overhead.

Concrete stairways at either end of the building give access to the mezzanine and second galleries, which are devoted to the switchboards, oil-switch compartments, reactance coils and other electrical equipment. Two such galleries extend the entire length of the station on the northeast side, and in the south corner are superimposed two smaller ones used as a machine shop and an office respectively. The sashes in the large side wall windows are operated in sections by a hand gear system, and the continuous bottom-hinged sashes in the roof monitor are operated by motors.

Water Turbines.—There are three 2,000-kw. main generating units in the hydro-electric station, each driven by a special, 50-in., vertical, single-runner, Francis turbine. Each has a maximum capacity of 3,600 h.p. when operating under an effective head of 75 ft. and at a normal

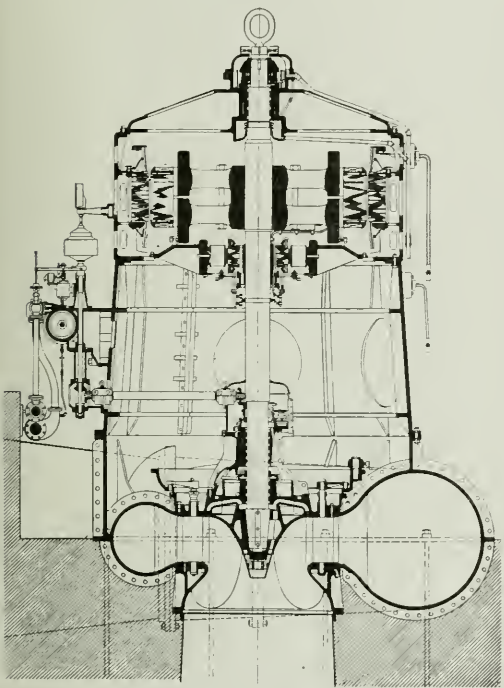


Arrangement of Switching Apparatus.

speed of 250 r.p.m. The centre of the runners is 20 ft. above tail water, and the discharge is through steel-lined concrete draft tubes 71 in. in diameter at the turbine and increasing to an elliptical section of 9 x 17 ft. at the outlets. The linings are of ¼-in. steel. A roller thrust

bearing mounted on top of the generator carries the weight of the revolving parts of both the turbine and generator. The turbine is so designed, however, that, when running at full capacity, the runner exerts an upward thrust of 10 tons, thereby relieving the thrust bearing of that amount of load.

Oil for the thrust bearing is supplied by a small pump geared to the turbine shaft, and a tank is provided below



Cross-section of Turbine, Generator and Exciter.

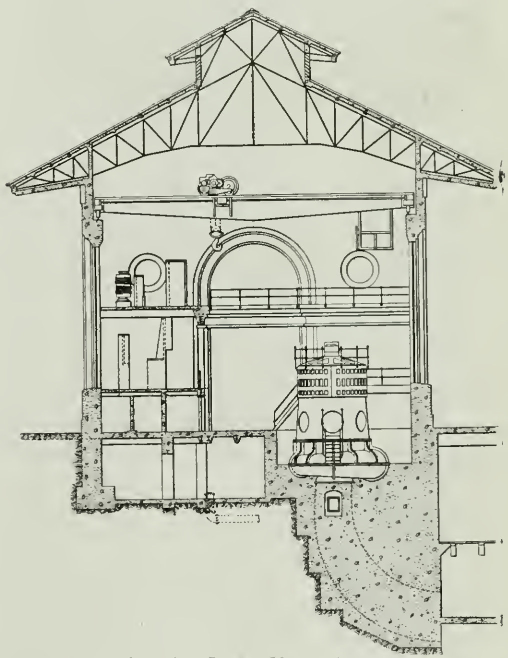
the pump to receive the overflow from the bearing. In this way a constant circulation of oil is maintained. As this oil returns to the suction tank, it passes through the lower guide bearing on the main shaft, lubricating it.

The runners are made of special bronze and weigh approximately 7,000 lb. each. They are taper bored and held in place on the lower end of the shaft by bronze nuts. The surfaces of the runner vanes are all hand finished to reduce hydraulic losses.

The speed of the turbines is controlled by Pelton oil pressure governors, mounted on the distance rings and driven by bevel gearing from the main shaft. Tachometers are mounted above the governors and are directly connected to the governor heads. The governors are fitted with small electric motors for varying the speed of the main units for synchronizing purposes, and a device is provided on each governor for varying the permanent drop in speed from no-load to full-load. This can be adjusted for any variation from 5 per cent. drop to absolutely constant speed from friction load to maximum load. The governors are also fitted with hand control mechanism for adjusting the gates independent of the oil pressure.

The wicket gates for controlling the supply of water to the runner of the turbine are steel castings with hand-finished surfaces. Each gate has its pivot stem extended upward through a packing gland and is fitted with an operating lever. All the gate levers are connected to the gate ring by means of bronze links, and the gate ring is connected to the governor rock-shaft. All the regulating mechanism is, therefore, outside the turbine case, except the gates themselves. The water passages on each side of the gates are provided with renewable rolled-steel wearing plates. Pressure oil for actuating the governors is supplied by two Pelton rotary pumping units, driven by 10-h.p. alternating-current motors at a speed of 375 r.p.m., each pump being capable of supplying the governors on all three units. The governors work on an open system, there being no vacuum chambers used. The discharge oil from the governors is led into oil-sump tanks, from which it passes into the suction of the pumps. Each oil pump is connected to a steel pressure-oil receiver with an air space above the oil. The oil-sump tanks and pipe connections are installed in duplicate, and valves are provided to enable one set to be cleaned while the other is in service.

Generators.—The three main generators are of a three-phase, 25-cycle, revolving-field type, developing 2,000 kw. at 0.8 power factor, 2,200 volts and 250 r.p.m. They have 25% two-hour overload rating, and are of General Electric Co. make. The exciter is mounted below the main generator but is readily accessible through large



Section Showing Power House Arrangement.

holes in the distance ring, a platform being provided inside the ring from which the exciter commutator and generator-collector rings may be reached. All windings were made moistureproof on account of extreme climatic conditions. Provision is made for securing the magnet frame of the exciter to the revolving element of the generator, so that the complete rotating element, together with the exciter frame, is raised at once in disassembling.

In addition, there are two motor-driven exciters. These consist of a 100-kw., 125-volt, 500-r.p.m. generator, direct-connected to a 150-h.p., 2,200-volt, 25-cycle squirrel-cage type induction motor. They are mounted on a common base plate and provided with three bearings. These exciters can also be used for charging the control battery.

Distribution System.—On account of the distance, current is transmitted at a voltage of 44,000 from the power station to both ends of the canal. The step-up transformers are, however, not located in the power plants, but in substations in their vicinities; therefore, the power plants generate and distribute only 2,200-volt current.

The system of connection throughout employs the double-switch scheme, with provision for disconnecting any oil switch for cleaning or repairs without interrupting the circuit. This system was naturally selected for this station because it was considered the most flexible for the requirement of uninterrupted service.

The double 44,000-volt transmission line runs across the Isthmus, connecting Cristobal and Balboa with the two power plants. There are four 44,000/2,200-volt substations stepping down at Cristobal and Balboa, and up or down at Gatun and Miraflores, depending on which of the two plants is supplying power. Thirty-six 2,200/240-volt transmission stations for power, traction and light at Gatun, Pedro Miguel and Miraflores locks have been provided. Three 2,200/220-110-volt transformer stations are installed for the control boards at the locks; and stations at Cristobal and Balboa for the coal handling plants, machine shops and drydocks.

The complete hydraulic equipment for this installation, including the racks, head-gates, pipe lines, Pitot tube testing apparatus, turbines, governors and oil pumping units, was designed and built by the Pelton Water Wheel Company; and all the electrical apparatus, including the generators, switchboards, transformers, head-gate motors, limit switches, float switches, etc., were furnished by the General Electric Company. All details of design and construction were subject to the approval of the Isthmian Canal Commission and its engineers.

Pittsburg business men, who are understood to be working in the interests of the Pickards Mather Company, of Cleveland, O., are investigating the iron deposits in the neighborhood of Savanne, a point on the C.P.R., about 75 miles west of Fort William, Ont.

Mr. P. C. Burpee, C.E., president of Concrete Builders, Limited, Fredericton, N.B., has made a business inspection trip throughout the principal brick-making cities of Quebec and Ontario, and has purchased a 10-inch tamper and brick machine, capable of making 10,000 bricks per day. It is the intention of the company to manufacture only fancy brick.

In connection with the extensive additions to be made by the Ford Motor Company, Detroit, Mich., which will double the capacity of its plant, and are to be completed this year, there will be erected a power house at a cost of about $5,000,000. It will be 240 feet long, 150 feet wide, and 85 feet high; and it is stated that it will contain the largest gasoline engine in the world, one which will drive motors that will produce 80,000 horse-power. Several buildings will also be constructed, each 900 feet long, 60 feet wide, and 6 stories high.

A new means of transportation is planned in the survey of the Saskatchewan River, which is to be completed this fall by engineers of the Dominion Public Works department. They have been engaged in the work for three years, and the idea is to have a 5-foot waterway from the Rockies to Winnipeg. This would be sufficient for barge traffic. The cost is roughly estimated at $15,000,000, the principal item of expense being a series of locks along the river. The total cost would be reduced by valuable water power to be developed along the route.

THE CARE OF WIRE ROPE.

EXPERIENCE has taught that there are four leading causes for the destruction of wire rope, namely, abrasion, overstrain, undue bending and corrosion. These, together with suitable methods to provide longer utility, are outlined in a recent issue of "Power," from which the following has been abstracted:

The cause of failure can usually be determined from the appearance of the rope. If, for example, the wires wear thin in a short time, the rope has been subject to abrasion; if the wires are but little worn and broken off squarely, usually sticking out all over the rope, it has suffered either severe bending stress or overstrain; and if the wires are rusty and pitted, corrosion is to blame.

Abrasion in a wire rope is frequently the result of: (1) Faulty grooves in wheels that are roughly worn or too tight for the rope. (2) Dragging of the rope upon the ground or over some fixed obstruction. (3) Using a rope under conditions for which none but the toughest steel (plough or improved plough) is adapted.

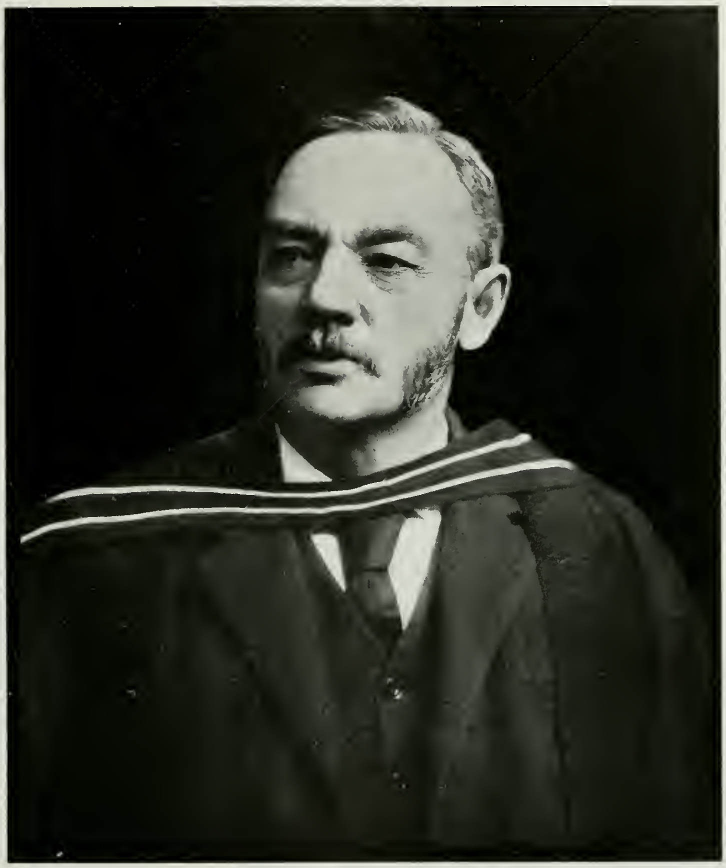
Badly broken wires, showing excessive bending, indicate that the wheels are too small or too numerous. Rope badly corroded shows the lack of proper lubrication.

In addition to the destructive causes mentioned above, ropes sometimes suddenly tear apart. Such cases are invariably the result of accidents to machinery or appliances, which bring upon the rope a load far beyond its capacity, or they are due to a serious weakening of the rope at the point of rupture, caused by some local abuses. One of the most common of these injuries is the damage arising from "kinking." If for any reason the rope is allowed to form a loop, and this loop is drawn taut, a kink will result. Though the kink may be straightened out, it leaves a permanently damaged and weakened spot and so should always be avoided. When a running rope has a socket attached to the end, constant vibration tends to weaken the wires, and this weakness is increased if water collects directly over the end of the socket. It is, therefore, advisable every three to six months to cut off a piece from the end of the rope and reattach the socket.

Besides the causes mentioned, the effects of which are usually revealed by inspection, temporary overloads producing excessive stresses are sometimes applied, and by straining the wires beyond their elastic limit tend to shorten the life of wire rope. Such excessive stresses are more apt to occur where a rope is slack, or is attached to a short length of slack chain, and the power to lift or haul a load is suddenly applied, with the result that, instead of the rope gradually adapting itself to the required pull, it is subjected to the jerk arising from the full inertia of the load. Lifting tests made on wire ropes, attached to chains having 2½ in. to 12 in. of slack attached, show that when loads are applied suddenly, the stresses are from one to four times as great as those sustained when the same loads are gradually applied.

When a complaint is made that a wire rope has not given satisfactory service, the first questions asked by the manufacturer are: "How was the rope lubricated?" "What is the condition of the inside wires?" These questions arise because the experienced wire-rope maker fully appreciates that a wire rope is a complex piece of machinery and knows that the importance of proper lubrication is too often overlooked.

A lubricant or preservative should not only penetrate to the hemp centre, in order to saturate it and prevent absorption of water, but it should also coat thoroughly the inside wires of each strand.



Born September 5, 1846
Died July 22, 1914

J. Galbraith

TRANSVERSE STRENGTH OF CUT SCREWS IN WOODEN JOINTS.

In *The Canadian Engineer* for March 14, 1912, an article was published giving the results of a nail test made in connection with the design of a hydro-electric plant at Sandy Falls, Ont. The purpose of the test was to ascertain the transverse holding power in pine lumber of 9-inch spikes (4½ to the pound), so that a well-proportioned joint could be designed. The results included several notable features of nailed joints, as follows:

(1) The permissible deflection value of 1/16 inch, i.e., the deflection which can be caused without weakening the joint is altogether too small. Joints tested to deflections of one inch or more seemed to be in no way weakened. This is a strong point in favor of the nailed joint.

(2) The percentage relation of elastic limit to ultimate load would depend on the assumed definition of the former. No satisfactory results were obtained, but they were sufficient to indicate that it is at least 50%.

(3) The relation between the strength of a joint and the number of nails is such that the former is proportional to the latter and quite independent of the arrangement provided failure did not occur by cracking of the timbers.

It is interesting to recall these tests in conjunction with similar ones, performed in Cornell University last year, to determine the transverse strength of ordinary cut screws in single shear in a wooden joint. The results were given in the Cornell Civil Engineer and from it the following has been extracted:

Three kinds of wood were used in the tests, cypress, yellow pine and oak. The cypress was fine grained and of uniform quality; its specific gravity was 0.442, and its rate of growth was 20 rings per in. The wood was thoroughly seasoned, and had a compressive strength of 4,980 lbs. per sq. in. The yellow pine was of a rather coarse but straight grain; its specific gravity was quite variable, the average being 0.648. The rate of growth varied from 8 to 15 rings per in., and this gave corresponding variations in results. The average compressive strength was 7,580 lbs. per sq. in. The oak was a good quality of red oak, well seasoned, of a firm straight grain and of uniform texture. Its specific gravity was of 0.701, its compressive strength was 8,440 lbs. per sq. in., and it had 20 rings per inch.

The test joint consisted of three pieces, each 12 ins. long and 6 ins. wide, the two side pieces B and B^1 (Fig. 1, a) having an 8-in. lap on the middle piece. The thickness of these pieces varied with the length of screw used, but the middle piece was always of sufficient length to cause the screws to be in single shear. The screws were arranged in the form of an equilateral triangle, the apex of the triangle being placed upward on one side piece and downward on the other (see Fig. 1, b). The test piece was subjected to compression, the forces acting as shown by the arrows in Fig. 1 (a).

It was found by experiment that screws could not be driven closer than 2½ ins. to an edge perpendicular to the grain without danger of splitting the wood. This distance was therefore used for all of the tests. It was found impossible to drive screws without previously boring holes, these holes having a diameter equal to that at the root of the screw threads. In oak, and where large screws were driven in yellow pine, separate holes had to be bored for the shank and for the threaded portion of the screw. A hole was also bored to receive the head of the screw, which brought the entire screw into action. In hard wood the driving of the screws was facilitated by lubricating them with thick, wet soap.

Method of Testing.—The procedure in testing was to measure the force at each 1/32-in. slip, up to a maximum of 6/32 in. This is more than would be allowed in any structure in practice, so it was not thought necessary to carry the test up to destruction. The deflection was measured by means of a steel pointer, attached to the middle piece, sliding over a celluloid scale, attached to the two outside pieces. The force was applied by turning the crank of the Olsen machine very slowly and at a uniform rate of speed. The result of rapid testing will be shown later. In making the tests it was found that the uniformity of results was materially affected by the bearing of the joint in the testing machine. To secure good results, it was necessary that the joint be so made as to have a full bearing on the table of the machine, and furthermore, that the axis of the joint be truly vertical.

Fig. 2 shows in a general way the forces acting on a screw in a joint. The screws were but slightly deformed in cypress, the wood being so soft as to crush readily without bending them. In yellow pine and oak, however, the screws were bent as shown. An attempt was made to derive a formula for the strength of a screw at a certain

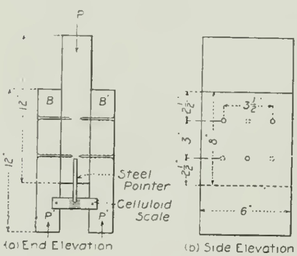


Fig. 1.—Arrangement of Screws in Test Specimen.

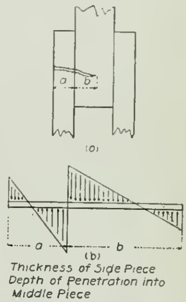


Fig. 2.—Distribution of Forces on a Cut Screw in Single Shear.

slip, but so many different factors, such as gripping of threads, amount of bearing, curvature of screw, etc., entered into the computations that it was found impossible to obtain anything of reasonable certainty.

Preliminary tests were made to determine the following items:

(1) Effect of driving, with and without boring holes.

(2) Effect of rapid testing.

(3) Effect of friction between adjoining pieces of the joint.

(4) Effect of varying the number of screws in the joint.

Effect of Boring Holes.—It was found, in the case of cypress, that there was a very small increase in the strength of the joint when the screws were driven without previously boring holes. In the case of yellow pine, there was a slight decrease in strength when no holes were bored.

The holding power of a screw driven in wood depends materially on the wood fibers securely gripping the screw threads; hence, if the screw is driven in such a manner as to break the fibers around the threads, the holding power will be decreased. The transverse strength, however, is not nearly so dependent upon the gripping of the threads by the wood as upon the bearing of the screw in the wood. In the case of cypress the fibers, not being broken in driving and being very soft, close tightly around

the screw threads and tend to increase the area of contact between the screw and wood, resulting in a slightly greater strength when driven without previously boring holes. In the case of yellow pine it is necessary to drive the screws with the hammer before using the screw driver. The fibers are therefore broken to a certain degree, resulting in a considerable decrease in the area of contact between the wood and the screw. This is probably the cause of the lower transverse strength in the case of the screw which has been driven without previously boring holes.

Effect of Rapid Testing.—When the load was applied too rapidly the values were not uniform, showing a great range as compared with those with slow testing. The values obtained by rapid testing averaged about 20 per cent. lower than the others. The difference was especially marked in the first few increments of slip, after which the values seemed to approach each other. This shows the importance of applying the loads slowly in tests of this nature.

Lubrication Tests.—The purpose of these tests was to determine what part of the strength of a joint is due to friction between the surfaces. It was found that in any case a lubricated test piece was but slightly weaker. It can therefore be assumed that the friction plays only a small part in the strength of the joint. The maximum difference between the lubricated and non-lubricated joints was shown in the first few increments of slip, the succeeding values showing little difference.

Effect of Variation in Number of Screws.—As the number of screws per joint is decreased, the strength per screw is slightly increased. This would naturally be expected, as the friction force remains constant in all the joints. An examination of the joints after testing showed that, as the number of screws per joint is decreased, there is a more uniform distribution of the total stress among the screws, thus giving a higher value for the joint.

Ratio of Strength to Penetration.—Curves, in which the load per screw, in pounds, was plotted against the slip, in inches, showed the following results:

In cypress, while a joint having a thin side piece may be stronger than one having a thick side piece during the first few increments of slip, it no longer continues to be so during the last few increments of slip. In yellow pine and oak, however, the thinner side piece remained the stronger throughout the entire slip. This is probably due to the fact that cypress, being softer, crushes after the first few increments of slip, and hence the difference in depths of penetration due to different side pieces affects the strength very little. In yellow pine and oak, the fibers remain intact a longer period, and therefore additional penetration gives additional strength. A number of typical load-slip curves for cypress are shown in Fig. 3, each curve representing an average of three tests.

An investigation of the relative thickness of side piece to the length of screw shows that, in general, the thinner side piece gives the stronger joint. A ¾-in. side piece and a 2½-in. screw gives a proportion of 0.3 between side piece and screw; and a 1-in. side piece and 2½-in. screw gives a proportion of 0.4. For a 2-in. screw the ¾-in. side piece gives the stronger joint, especially with the smaller gauges, the proportion being 0.385. For a 1½-in. screw the best joint was obtained with a side piece of ⅝-in., the proportion being 0.4. Thus it seems that a side piece about 0.4 of the length of the screw gives the strongest joint. Decreasing the thickness of the side piece increases the strength of the joint up to a certain limit, this limit being reached when so little bearing area is provided in the side piece that the wood is rapidly crushed.

The strength of a screw, for a particular gauge, is independent of the length, but depends on the penetration into the middle piece. Thus a 3-in. screw with a 1½-in. side piece (1½-in. penetration) shows practically the same strength as a 2½-in. screw with a 1-in. side piece (1½-in. penetration), the gauge remaining constant.

In yellow pine or oak the ratio of strength to penetration is very closely proportional to the square root of the penetration into the middle piece. For cypress the strength was found to be directly proportional to the cube root of the penetration into the middle piece. These laws, however, will not hold if the side piece is made much less than 0.4 of the length of the screw; decreasing the side piece beyond this point, while giving a greater penetration into middle piece, will give a weaker joint, due to insufficient area.

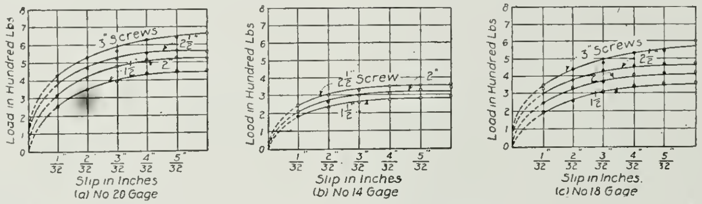


Fig. 3.—Relation Between Lengths of Screws, Load per Screw and the Slip of Nos. 20, 14 and 18 Gauge.

Transverse Strength Per Pound of Screws.—The following laws were deduced showing the transverse strength per pound of screws in the different woods:

(1) For a particular length of screw, the smaller the gauge the greater the strength per pound of screws.

(2) As the length of screw is increased, the gauge remaining constant, the transverse strength per pound is increased.

(3) As the gauges become larger, the difference in transverse strength per pound between screws of different lengths tends to become more nearly equal.

The curves in Fig. 4 show clearly that as the number of screws per pound is increased the strength per pound is increased, irrespective of the length or gauge. However, in actual practice, the additional labor cost of driving many small screws rather than a few large ones would offset the advantage of greater strength.

Relative Strength of Screws in Different Woods.—By taking the average strength of all tests made it was found that yellow pine was about 80 per cent. as strong as oak, and that cypress was about 40 per cent. as strong as oak. A comparison of the compressive strengths of these woods shows yellow pine to be about 92 per cent. as strong as oak, and cypress to be about 59 per cent. as strong as oak.

An attempt was made to establish a relation between the transverse strength per screw and the gauge or diameter, but no relation could be found.

The report contained tables giving the strength per screw, in each kind of wood, for increments of slip of 1/32 in. In yellow pine the strength varied with the specific gravity of the pine. After reducing all values to a common standard a difference of 0.1 lb. in the weight

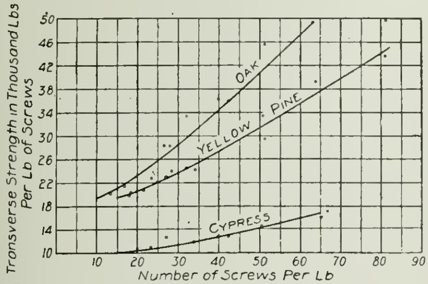


Fig. 4.—Relation Between Number of Screws per lb. and Strength per lb. of Screws.

of a joint was found to make a corresponding difference in strength of 10 lbs. at 1/32-in. slip and 30 lbs. at 3/16-in. slip. The following conclusions were drawn from the tests:

(1) In cypress the effect of boring holes for the screws is to slightly weaken the joint.

(2) In yellow pine the effect of boring holes for the screws is to slightly strengthen the joint.

(3) The effect of rapid testing is to give weaker joints and non-uniformity of results.

(4) Friction between adjoining pieces plays only a small part in the strength of the joint.

(5) Decreasing the number of screws per joint increases slightly the strength per screw.

(6) To secure the best results in a wooden joint, the outer piece should be about 0.4 the length of screw.

(7) For a particular gauge, equal penetration into the middle piece will give equal transverse strength, regardless of the thickness of the side piece, provided it supplies sufficient bearing area.

(8) The transverse strength per screw in yellow pine or oak varies directly as the square root of the penetration into the middle piece.

(9) The transverse strength per screw in cypress varies directly as the cube root of the penetration into the middle piece.

(10) For a particular length of screw the smaller the gauge the greater the strength per pound of screws.

(11) As the length of screw is increased the strength per pound is decreased, the gauge remaining constant.

(12) As the number of screws per pound is increased, the strength per pound is increased, irrespective of length or gauge.

(13) The strength of a yellow pine joint is about 80 per cent. of that of an oak joint.

(14) The strength of a cypress joint is about 40 per cent. of that of an oak joint.

(15) There is no apparent simple relation between gauge or diameter and transverse strength.

(16) The smaller the gauge the more economical the screw, the length remaining constant.

(17) The gauge remaining constant, the shortest screws will be most economical.

(18) The most economical screws of those investigated were: 2-in., No. 12 gauge; 1½-in., No. 8 gauge; and 1½-in., No. 12 gauge.

THE FUNDAMENTALS OF MINING EFFICIENCY.

THE following suggestions for increasing efficiency in mining operations, while not new, are such that, if conscientiously followed, an increase in production or a decrease in costs should be the result. While pertaining chiefly to mining, they apply with almost equal force to engineering construction and industrial work. They were presented in the Engineering and Mining Journal recently by Wilbur Meyers, of Negaunee, Michigan:

Efficiency in mining is as old as the industry itself. It is attained by the systematic analysis of existing conditions with continual study of how to improve these conditions so as to make operations safer and more productive for the same expenditure—this, combined with a common-sense attitude toward the ever-occurring emergencies that are a part of the business.

There are certain fundamental principles of efficiency that will apply whether mining is being carried on for coal, iron, gold or any other substance. The nature of mining makes efficiency particularly important. The policy of letting well enough alone because a routine management is paying small profits, is unreasonable when it is remembered that the wealth of the property is being exhausted and that there is no future chance to recover the money lost from year to year in producing at a higher cost per ton than was absolutely necessary. The main avenues of cost in any mine are labor and supplies; there are other expenses that must be met, such as taxes, insurance, royalties, personal injuries, legal expense in connection with damage suits, etc., but the cost of labor and the cost of supplies are the two great factors in mining costs, labor being the greatest of these two. One of the first necessary operations in introducing an efficiency scheme is to secure the good will of the workmen, since a contented workman in full sympathy with progressive ideas is much better material to work on than one suspicious and dissatisfied, antagonistic to innovations, which he fears are part of some new scheme to get the best of him. It is peculiarly necessary to get the good will of mine employees, since they work in isolated places, incapable of constant supervision. While it may be true that their work can be gauged by results obtained, yet these results will often be the maximum of the second- or third-class workman, the best workmen being afraid to let themselves out to their full capacity for various reasons. The management could do something to win and hold the good will of its workmen by getting their viewpoint, based on personal knowledge of working and living conditions.

Better light in the mine would be of benefit to the miner, eliminating some of the hazards surrounding his work and increasing productiveness, since he could detect and secure dangerous places more quickly, facilitating his work in different ways; it would help not only the miner but also the operator. Better ventilation, good drinking water, sanitation; all these have a direct bearing on a miner's comfort and safety, and incidentally on his productiveness, for as soon as the workman sees that the management is improving things for his benefit, he will begin to co-operate and his good will is won.

Harmony between different departments is another fundamental requisite of efficiency. Friction wastes power with men as well as in machinery. Sometimes there exist petty jealousies between the practical miner who has obtained his knowledge by years of experience and the engineer who has graduated from college after a four- or five-year mining course. Both types of men

are necessary and working in harmony each helps the other, while the company gets the best results from both. Sometimes the men at the shaft-top fail to work together with the men below, signals are misinterpreted, hoisting is delayed, etc. A smoker or concert occasionally, even a picnic, will get the men together in a happy frame of mind and eliminate a lot of petty jealousies.

One great aid to efficiency is the bonus or premium system, or profit-sharing with the employees; this identifies the interests of the workmen with the interests of the company. Such a system properly administered will enable the miners to earn more money per day and the company to produce at a lower cost per ton.

Education of the workmen is of the greatest importance. Either the boss or a skilled fellow employee as a companion, can show the green workman how to obtain a maximum result with the minimum expenditure of labor and also how to detect and secure dangerous places. Racial characteristics can be taken advantage of in this way, thus an old experienced Italian could have a younger man of his own nationality put with him to good advantage. If increased pay is given for increased production, this plan will stimulate both men to their best.

A suggestion box to enable the more intelligent workmen to submit to the management plans for improvements in methods often yields practical and economical ideas. If these are paid for and proper credit given to the workmen submitting them, it is an incentive to draw out the best working ideas.

If the foremen of different departments where the work is similar, are made to hand in to the office daily reports made out on standard blanks, a comparison of production and of accidents under each foreman can be made and friendly competition stimulated among the foremen, especially if the reports are known to be the basis for promotion.

Standardizing equipment and supplies will tend to reduce the quantity of supplies carried in stock and the amount of money tied up at any one time, and will facilitate repairs, inasmuch as the workmen will become acquainted with the kind of supplies needed and used and transfers of both equipment and supplies can be made from one part of the mine to another. If tracks of different gauge are used for tramming, there must of necessity be various sizes of equipment such as cars, motors, etc., and this equipment would not be interchangeable, whereas if all tracks are standardized, changes can be effected readily. Again, trolley wire may be either grooved, figure-8 or round; if two or three of these sections are used, there will usually be necessary two sets of supplies to accompany the wire; while if one kind is used throughout the mine, both on the surface and underground, there can be no misunderstandings when trolley wire is ordered.

Recovering timbers, rails, switchpoints, frogs, rail spikes, pipe, trolley wire, hangers, etc., from places that are to be abandoned, or caved, instead of allowing them to be buried, will materially decrease the total expenditure for supplies. If supplies are standardized, this recovered material can be used at once, being already underground, and a saving of time secured, because new supplies would have to be taken out of the mine warehouse and sent below.

Workmen can be educated to economy in the use of supplies. The common waste of oil by motormen is unnecessary. Miners often break or lose their tools when they do not like them, or when they want new ones, but if they have to return the old tools to get new, or else be charged for the new, the management will be pretty sure of getting maximum length of service from all tools issued.

Prompt return of dull tools to the blacksmith shop for resharpening is another practice that makes for efficiency. Where two shifts are worked, it is a common thing for one shift to leave its dull tools for the next shift, rather than to take them out.

Discretion in the choice of supplies is important; many joints are made with high-priced sheet packing when cheaper packing would serve the same purpose, or even asbestos roll-board or mill-board costing about one-quarter as much. Or take the common spike used for a 30-lb. rail, the size is either $3\frac{1}{2}$ x $\frac{1}{2}$ in., or 4 x $\frac{1}{2}$ in.; the cost, including freight from the wholesale house to the mine, will be approximately one cent per spike. The $3\frac{1}{2}$-in. spike runs about 140 more to the 200-lb. keg than does the 4-in. There are places where a $3\frac{1}{2}$-in. rail spike can be used instead of a 4-in. resulting in a possible saving of $1.40 per keg. Rail spikes are an excellent illustration, because so many are wasted in almost every mine, and in most mines are not recovered for use a second time, yet every 4 x $\frac{1}{2}$-in. spike saved represents a saving of approximately one cent.

A NEW GOVERNOR FOR WATER TURBINES.

Fig. 1 illustrates an improved governor for water turbines, designed by Percy Pitman, London, Eng. The characteristic feature of the device lies in the fact that floating levers have been entirely dispensed with. The inventor claims it to have a close speed regulation without hunting, to have all parts adjustable while in operation, and to be automatic, hand or distant controlled.

Referring to the figure, the governor sleeve is mounted on an aluminum crosshead *C*, which rises and falls with the sleeve *S*, it is adjustable to take up wear, and is prevented from revolving by stops. One end of the crosshead is directly connected to the piston valve *J* and the other end to the plunger of the oil brake *W*; this gives a direct force couple.

The compensating mechanism consists of a bronze sleeve *E*, which is a sliding fit in the valve body *A*, and inside of which the plunger *J* works. The sleeve is connected to the piston of the servomotor, as shown, or to some part of the gate-regulating mechanism; therefore, every movement of the piston valve is immediately duplicated by the sleeve.

An oil brake *W* is provided with a wide range of adjustment by means of the check valve *Y*. This controls the too rapid action of the governor, and prevents the valve sleeves or compensator from interfering with the action of the pendulum.

The body of the oil brake is coupled to the valve sleeves by the rocking beam *Z*, so that when the speed is changed and the valve sleeve moves upward, the compensating action causes the oil-brake body to move downward, and *vice versa*. The check valve *Y* on the oil brake can be so adjusted that, however sudden the change of load, the action of the governor pendulum is not interfered with by the back action of the sleeve. The rocking beam *Z*, the sleeve *E*, and the oil-brake body *W* are held rigid between every movement of the pendulum.

In the case of an impulse wheel with needle regulation or with a deflector, if it should be noticed that the governor carries a needle or deflector beyond the proper position and then oscillates several times after a change of load, it indicates that the oil brake is not slow enough

in its action. The remedy is to close down the valve *Y* still further. If the governor does not open or close the nozzle properly, the valve on the oil brake is unscrewed a little more.

Another feature of the governor is that of throttling the exhaust instead of the supply to the valve *A*. This arrangement takes some of the strain off the piston valve, resists the wear, puts it in more perfect balance, and makes the relay piston easier to move.

The crosshead is fitted with double-ball thrust bearings to take the end thrust in either direction. The bottom of the main spindle also has a double ball-thrust bearing *H*, and the bearings at the top and bottom are ball-journal bearings, as at *N*.

The horizontal driving spindle is provided with two radial ball bearings *P* and a double thrust bearing *Q*, to prevent any tendency to end movement and take the thrust of the driving gear.

The inventor claims that the great advantage of using oil for the relay is that the parts require no lubrication and the wear is negligible. The best oil to use is a pure hydrocarbon, which must be without mineral or free fatty acids. It should have a low settling point, and must remain liquid at low temperatures. It is important to

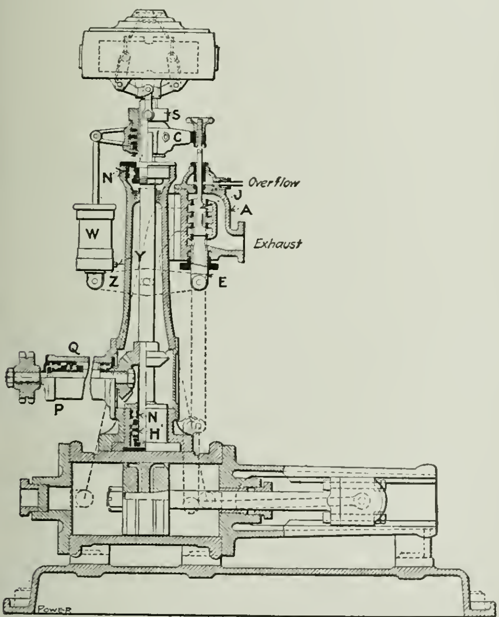


Fig. 1.—Sectional View of Hydraulic Governor.

select an oil suitable for the climate and the conditions under which it will be used. The viscosity of oil diminishes as the temperature rises, oils of high initial viscosity giving way more rapidly than oils of lower viscosity. An oil should be chosen which does not break down into vaseline after long use. Sometimes a really first-class oil, although it does not affect leather to any appreciable extent, is liable to affect packing-rings of the composition class, such as vulcanite or fibre, and its action on these is greater in hot climates. In cold climates a mixture of alcohol and glycerine can be used in place of oil to prevent risks of freezing.

THERMAL MEASUREMENT OF STRESS.

At one of his Cantor lectures before the London Society of Arts, Prof. E. G. Coker took up the subject of thermal methods of measuring stresses. He first dwelt briefly upon the history of the study since the discovery, by Magnus, that changes of stress were accompanied by slight changes of temperature. Then he gave a practical demonstration of a specimen, subjected to tensile stress, exhibiting a lowering of temperature, which was measured by a thermopile attached to a reflecting galvanometer. Of course, the experiment necessitated a careful protection of the specimen under examination from air currents, and flow of heat from surrounding objects. Such difficulties admit of easy control in a properly-equipped laboratory, and under proper working conditions. The illustrations are remarkably in evidence.

In discussing the phenomenon, Prof. Coker stated that the change in question was not to be confounded with the large and sudden rise of temperature observed when a specimen was stretched beyond its elastic limit, since within the elastic limit the stretching of a bar was accompanied by a fall, and not by a rise, of temperature. The theory of the matter had, he claimed, been worked out by Lord Kelvin, who deduced the following connection between the change of temperature and the change of stress:—

$$\Delta T = -\frac{T\alpha}{Js\rho}\,.\,\Delta p.$$

In this formula ΔT denotes the change of temperature corresponding to the change of stress Δp. T is the absolute temperature of the specimen, α its coefficient of expansion by heat, J Joule's equivalent, s the specific heat of the material under constant pressure, and ρ its density.

In the case of steel this density may be taken as 7.5 and the specific heat as 0.11 at 20 deg. Cent., while α was 1.2×10^{-5}, so that we get:—

$$\Delta T = -0.000012\,p.$$

The order of the effect is better shown by the following table:—

Stress. Lb. per Sq. In.	Temperature Cent. Tension.	Compression.
0	20.0	20.0
5,000	19.94	20.06
10,000	19.88	20.12
15,000	19.82	20.18
20,000	19.76	20.24

Thus a change of stress from 0 to 20,000 lb. per sq. in. produces a change of temperature equal to only about ¼ deg. C.

It is assumed in the above formula that the specific heat of the material and its coefficient of expansion are independent of the stress. The former assumption has not been actually tested, but it is very unlikely that the specific heat is sensibly different in strained and unstrained material. That the coefficient of expansion is independent of the stress has, however, been proved in Prof. Coker's laboratory in the case both of mild steel and brass.

Joule was, according to Prof. Coker, the first to test the accuracy of Kelvin's law, which he proved to be true for a considerable number of materials, using thermoelectric couples inserted in holes drilled in the specimen. In the speaker's own experiments he had simply pressed a thermopile against the surface of the test-piece, insulating it by a layer of thin paper or a coat of insulating varnish. It was essential that the load should be applied

to the specimen at a uniform rate, because the actual galvanometer readings had to be corrected for an inflow of heat by conduction and convection; and since these corrections were effected by means of "cooling" curves, it was necessary that the scale of time should be proportional to the scale of loads. A set of readings taken on a tension specimen were, the speaker continued, shown by the rising portion of the lower curve in Fig. 1. After the maximum stress was attained, the specimen was allowed to warm up, which gave the descending portion of the curve shown, and from this the rate of heat gain at any temperature could be deduced. It was assumed, for such small changes of temperature as were involved in experiments of this kind, that the rate of heat-flow was proportional to the temperature difference, and on this assumption it could be shown that the observed galvanometer readings should be multiplied by the factor $\frac{1}{2}\, c\, t\, D_t$, where D_t was the observed reading at the time t and c a constant deduced from the "cooling" curve. In this way the corrected curve shown by the upper curve in Fig. 1 was obtained, which corresponded, it would be seen, to a straight line law, the temperature rise being, therefore, proportional to the intensity of the stress.

It had at one time been thought that, by these thermal methods, an elastic limit could be detected below that observed in the ordinary methods of testing. The speaker had, however, found that this was not the case, the yield-point, as determined by mechanical means, coinciding with that indicated by the sudden heating of the bar. This was well illustrated in Fig. 2, where the two curves to the left were obtained thermally, and that to the right by an ordinary extensometer. When the yield-point of a bar was raised by stretching it beyond the elastic limit, the "thermal" yield-point was also raised to exactly the same extent.

Since a compression caused a rise of temperature, and a tension a fall of equal amount, thermal methods gave, he said, no indication of the existence of shearing stresses, since every shear could be replaced by a tension and a compression acting at right angles to each other. On the other hand, if a specimen were simultaneously subjected to two tensions at right angles to each other, the temperature change would be the sum of that due to each. Hence, if a channel, such as shown in Fig. 3, were subjected to bending, and an attempt were made to determine the stresses at different points by the thermal method, the results did not indicate the same linear distribution of stress as could be proved to exist by the extensometer. The curves yielded by the thermal method were, in fact, of the type represented in Fig. 4, and showed a marked departure from the straight-line law. This arose because a channel was not a symmetrical section, and when subjected to bending, the web also bent in a transverse plane. The thermal method added the stresses due to this warping of the web to those directly due to the bending moment, giving thus the results indicated in the figure. In an I-beam the web remained straight, and the thermal method gave results in exact accordance with ordinary extensometer observations.

Thermal methods of detecting changes of stress were, the speaker added, applicable to other materials as well as to metals. Excellent results had, for example, been obtained with a beam of slate. With cement and concrete, however, the results were discordant, unless the concrete was of an age measured by years rather than by months.

Since stressed and unstressed materials had different thermo-electric properties, it had been suggested that these might form a basis of stress measurements. Ewing's researches had, however, shown the phenomena to be of too complicated a character for this suggestion to prove fertile, and this conclusion was confirmed by the work of later investigators.

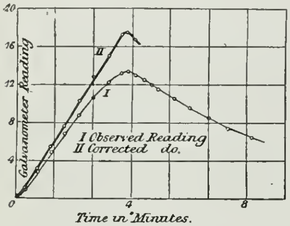


Fig. 1.

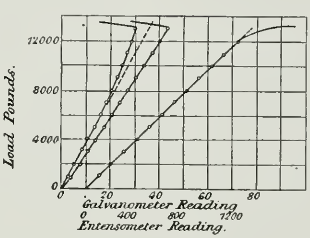


Fig. 2.

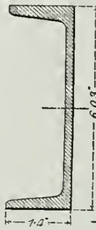


Fig. 3.

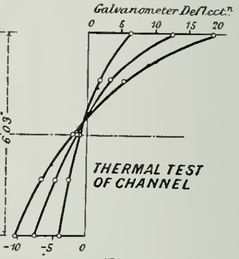


Fig. 4.

DEMONSTRATIONS OF STEEL FORMS.

M. S. Hotchkiss, president of the Hotchkiss Lock Metal Form Company, of Binghamton, N.Y., and three of his sales representatives, are making a tour of a number of Ontario towns and cities, demonstrating steel forms for sidewalks; curbs; combined curbs and gutters; combined walk, curb and gutters; street crossings; driveways; etc.

A number of orders have been received for these forms. Mr. Hotchkiss states that sales have previously been made in every province in Canada, and he is confident that steel forms will soon entirely supplant the old style wasteful wood forms.

The Hotchkiss Company have just issued a new catalog, entitled "Sidewalk Science," illustrated with views of their work, a number of which views were obtained in Canada.

Mr. Hotchkiss states that the amount spent by the average sidewalk contractor for lumber in a year would more than equip him with an outfit of steel forms which would last him a lifetime. These forms are very simple, the sidewalk forms, for instance, being composed of only two parts—the side rails and the templets, or dividing plates, which lock into the side rails. The side rails give perfect alignment and true surface, while the dividing plates provide an absolute cut and complete expansion. When put into position, they make a perfect form without the use of stakes or braces, and it is claimed that better work can be done with the steel forms than with the wooden forms, even when the construction with the steel forms is rushed at a much faster pace than is possible with wooden forms.

At the last meeting of the Lachine town council it was decided to see what could be done toward establishing better connections between Lachine and Dominion Park by writing to the Railway Commission with a view to building a tunnel on Sixth Avenue.

WATER SOFTENING BY MEANS OF PERMUTIT.

THE use of an artificial zeolite, known as permutit, for the purpose of softening water has recently undergone a two years' test in the boiler house of the government laboratories at Moscow. The advantage of the new process is that it requires only one filtering operation.

When hard water is slowly filtered through a layer of permutit, the lime and magnesia replace the soda in the substance; the soda passes into solution, so that an alkaline water flows off, while the lime and magnesia are retained by the permutit. When the permutit has become exhausted, it is regenerated by letting a solution of common salt enter through the layer from below; this time the chlorides of calcium and magnesium pass into solution, and the soda is retained by the permutit. The questions are: Can this exchange go on indefinitely and can the filtration be entrusted to a laborer, or does it require constant control by a chemist?

In the Moscow experiments, as described in "Engineering," two tubular boilers had in 1908 and 1909 been fed with water from an artesian well, the water not being treated in any way. A litre of water left 465 milligrammes of residue (88 mg. being CaO, 58 MgO, 131 CO_3, 7.4 Cl, and 0.4 mg. Fe); the total hardness was 16.9, and the temporary hardness 5. So much scale was deposited in the boilers that two permutit filters of cast iron, each charged with 230 kg. of permutit, were installed in January, 1910; they were used on alternate days, for filtration one day and for regeneration the next day. The permutit supplied was of coarse grain, the lumps being from 2 mm. to 5 mm. in diameter, and of the high water percentage of 55. The exchangeability percentage of the Moscow permutit was low, 1.35, as compared with the 2 per cent. now attained; this figure indicates the weight of CoO, expressed in per cent. of the total weight of the permutit, which is taken up from calcium-sulphate solution of 100 degrees of hardness. The rate of filtering was slow, 1.5 m. per hour. After filtering 8.6 cu. m. of water the filter was regenerated with a solution of salt containing 2.5 kg. of salt per cu. m. of soft water.

It had been noticed in the preliminary experiments that the filtered water had certain peculiarities, and when the filtering was prolonged beyond the exhaustion of the permutit, the filtered water contained increasing amounts of magnesia, and remained free from lime. Only when 62 mg. of MgO were found, did lime begin to appear in the filtered water. The investigation of this point showed that equivalent amounts of bases did not replace the same amount of soda in the permutit, but that the amount replaced increased. The permutit hence became sooner exhausted with regard to magnesia than with respect to lime, and as the water in question was comparatively rich in magnesia, considerable quantities of magnesia appeared in the filtrate before any calcium oxide passed through the filter. In calculating the amount of permutit required for softening water of a certain hardness, the lime hardness should hence be distinguished from the magnesia hardness.

When the filter was used for too long a period the filtered water contained magnesia, which would render it hard. This magnesia, however, proved harmless so far as scale formation was concerned. It made the water turbid; but the alkaline water cleared by settling, and the mud deposited was soft and could easily be removed from the boiler by a jet of water after six weeks' working; and no hard incrustation was found when the experiments were finally interrupted after two years of working. Thus it would appear that magnesium oxide (or rather hydroxide) did not create boiler scale, and that the control of the process is much more simple than might have been thought.

The records of the boiler performance demonstrated that the evaporation figure had been improved by 4 per cent. by the permutit treatment, although a poorer coal was being burnt in 1911 than before, evidently because the boiler-plates were now free of scale. The saving thereby effected was sufficient to justify the estimate that the softening plant would pay for itself in five years, provided that the permutit continued to do its duty. Careful observations showed that after two years the permutit operated as well as on starting and on weighing and analyzing the material a loss of only 3 per cent. was found. Thus permutit may be used for purifying water containing iron. The brass fittings on the boiler did not suffer from the permutit water, provided the boilers were blown off every day to prevent concentration of the soda in the water. This, however, does not prove that really high pressures and high superheating might not lead to corrosion in boilers fed with permutit-filtered water.

The investigations show that permutit softening cannot always be recommended. Sometimes the soda-lime treatment would be preferable. Water which runs turbid through a sand filter and is slimy is better treated with lime; as are also waters of very great hardness, or merely of high temporary hardness (rich in bicarbonates), for which the old softening would be cheaper. Where the price of salt is very high, the generation of the permutit may become too expensive. Little is to be gained by the sometimes advocated combination of the two processes, which would require an expensive plant and call for constant supervision by a competent chemist.

In connection with the Moscow tests, Mr. F. W. Hodson, M.Inst.C.E., of London, writes:

It is the common experience of all engineers who have been responsible for the adoption of softening plants with lime or lime-and-soda treatment, either for town or industrial purposes, that with most waters the performance of the softening plant, whatever its type, is not as perfect in practice as in theory, and that an after deposit occurs in the pipes and tanks through which the water passes after treatment. The effect of this may vary in importance from a considerable reduction in the diameter of a town's water-mains to a negligible accumulation of soft sludge in a boiler; but even in an industrial works it frequently leads to trouble and expense in connection with the stoppages of feed-pipes, valves, and economizers, and in numbers of cases has led to the abandonment of the softening plant installed.

Permutit apparently seems to offer a solution of this difficulty, for I have now had for several months comparative samples from a lime-soda softener plant before and after the water was passed through a sodium permutit filter. The former have varying amounts of deposit, the latter are perfectly clear. There are now three methods of using permutit:

1. By softening the water to zero with sodium permutit, and regenerating with common salt as described in the Moscow experiments.

2. By first softening the water with lime and finishing with sodium permutit in a smaller filter, and regenerating with a correspondingly reduced quantity of salt, owing to the prior removal of a portion of hardness.

3. By softening with lime and filtering through calcium permutit, and regenerating by washing back with raw water, thus saving all cost of salt. Calcium permutit has the remarkable property of being able to absorb free

caustic alkali, and of giving it up to water containing bicarbonates, and thus acts, within limits, as an automatic chemical regulator on the lime-softening operations, but without materially modifying the hardness of the water with which it is supplied. By acting also as a mechanical filter, it takes out the carbonate of lime remaining in suspension from the softening tank.

The practical questions which arise are in what cases, and with what class, of waters, are the lime and soda process, or the permutit process with its modifications, most suitable for use, and what are the relative costs of working in pence per 1,000 gallons treated.

For industrial purposes, in some cases considerations of space occupied by the plant would have a considerable influence in modifying the choice, and for the same quantity of the same water the sodium-permutit zero plant would apparently occupy much less area than the tanks and apparatus of a lime-soda plant. The choice may be further modified by the final composition of the water in respect of the purposes to which it is to be put, as a considerable difference can be made by adopting the sodium-permutit zero plant, in which all the calcium and magnesium salts are replaced by soda, or by adopting the lime process first, in which case only the permanent hardness is replaced by soda, and practical experience in the difference in composition of the resulting treated water would be of great value if any comparative results from combined lime-soda and permutit plants are available in this country.

The conclusion arrived at by Bahrdt, that little is to be gained by the combination of the two processes seems to require modification from this point of view, and it is also difficult to see why the combination should require the constant supervision of a chemist to any greater extent than lime-soda plant always does, as the permutit filter would tend to take care of the errors made in the lime-soda plant.

It also appears from Bahrdt's experiments that, as in the lime-soda process, magnesia is more difficult to remove than lime. In the older process the time element appears to have great influence in the result, and it may be that in the zeolite process the depth of the permutit, as influencing the length of time the permutit is in contact with the magnesia, may have a bearing on the results found.

PUNCHED HOLES IN STRUCTURAL STEEL.

IN "Le Genie Civil," C. Birault, chief of the department of testing materials of l'Ecole Centrale, Paris, discusses the effect on the elastic limit and tensile strength of drilled and punched holes in mild steel, such as is usually employed in building construction. He claims to have established that the resistence to rupture of solid bars, and perforated bars of the same metal, is not proportional to the section of the bars, making proper allowance for the perforations. Section for section, the advantage is in favor of the perforated bars if the holes have been drilled. The holes weaken the steel much less than would be expected, provided care is taken in drilling the holes, and in reaming them after they have been punched; and the elastic limit and the resistance to breaking are higher than before drilling.

Three bars were cut from one piece of steel. One bar was pulled in its original condition; the second bar was perforated with two drilled holes located on the small axis of the bar, and the third bar was perforated similarly, except that the holes were punched. The holes in each case were of 15 mm. diameter, and spaced three diameters from centre to centre. Several series of tests were made. The writer refers to a set of 3 bars from the same steel, the fractured ends placed in contact. The plain bar elongated more than the other two, since the molecular fatigue was less than in the perforated bars. The bar with the drilled holes (the middle one) elongated further than the one with the punched holes, and the holes were decidedly oval, which was not true of the punched holes. Comparison of the two perforated bars showed how the drilling or punching modified the properties of resistance. The fracture of the punched bar was not along the diameter of the holes, probably due to fissures in the metal caused by the action of the punch. The bar with drilled holes parted on their centre line. The numerical results also supported the evidence in favor of drilled holes. The results of three sets of tests were as follows:—

	Elastic. Limit, Kg.	Tensile. Strength, Kg.
Set from first bar—		
Plain bar	24.4	39.2
Bar with drilled holes.....	31.4	43.5
Bar with punched holes....	33.4	37.6
Set from second bar—		
Plain bar	23.4	37.9
Bar with drilled holes.....	29.3	43.3
Bar with punched holes....	31.3	36.5
Set from third bar—		
Plain bar	25.7	46.1
Bar with drilled holes.....	29.4	49.4
Bar with punched holes....	34.4	34.8

It will be noted that the elastic limit is higher for the bars having perforations than for the plain bars, with an increase for the punched holes over the drilled; while in tensile strength there is an increase for the bar with drilled holes, over the plain bars, the bars with punched holes losing decidedly in strength as compared with the plain. Averaging the results in terms of percentage, the bars with drilled holes have 12.3 per cent. greater average elastic limit, and 9.2 per cent. greater average tensile strength than plain bars of the same steel; while the punched bars show an average increase of 13.5 per cent. in elastic limit and an average decrease of 8 per cent. in tensile strength, as compared with plain bars of the same steel.

The author finds upon bringing into contact the fractured ends of the plain bar, that the two parts are not complementary; that there is a hollow space near the centre where the metal has evidently drawn away first, the break then proceeding gradually to the two sides. If, however, the metal is perforated with smooth drilled holes, not having fissures as in punched ones, this tendency of the metal to separate and weaken is removed, and the mean resistance to rupture is more uniform.

These tests show that insistence cannot be too strong on the practical importance of reaming punched holes in mild steel, a practice too often neglected for economical reasons.

A report of activities at Moncton, N.B., for the month of June states work is progressing on the diverting branch from Nelson to Derby Junction on the Intercolonial Railway. On the Canada Eastern branch of the Intercolonial Railway twenty-three miles of 80-lb. rails are to be laid; and about 40 miles of track reballasted. The new brick station at Bathurst was completed, and the brick and stone station at Sussex nearly finished. Also the block signal system is being installed on the double track between Moncton and Parrisee, and from St. John to Hampton.

AN INVESTIGATION OF COARSE AGGREGATES FOR CONCRETE.

IN an endeavor to develop some useful form of test for the coarse aggregates in concrete a method worthy of careful investigation and further development was described recently by Mr. Cloyd M. Chapman before the American Society for Testing Materials at its convention, June 30th to July 3rd, 1914, in Atlantic City, N.J. The method was used in the laboratories of Westinghouse, Church, Kerr & Company, New York, and consists essentially in determining the compressive strength of a specimen made up of a skeleton structure of the material under investigation. The interstices of the structure are filled with a standardized neat cement or a cement-sand grout in a sufficiently fluid state to flow into and fill all the voids. Before the grout is poured in the pieces of stone are in close contact with one another, the grout acting as a binder, holds the cement in place and prevents slipping of one upon another during the test. Mr. Chapman, who devised the method, submits that the compressive strength is a function of many variables in any case, but observes that it is probably of a less number in a specimen made up in this manner than in one in which the stone and grout are mixed together to make the concrete before being placed in the mold.

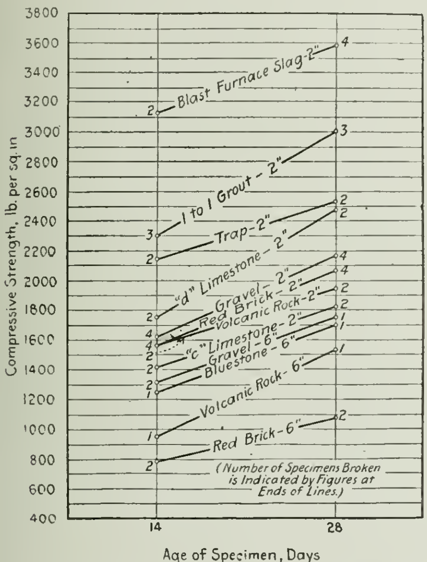


Fig. 1.—Compressive Strength of 1:2:5 Concrete in the Form of 2-in. Cubes and 6-in. Cylinders.

The details of manipulation are described by Mr. Chapman as follows: The molds used are 6-in. cylinders, 6 in. high, and 2-in. cubes. The size of stone used is ¾ to 1¼ in. (averaging about 1 in.) for the 6-in. specimens, and ¼ to ½ in. for the 2-in. specimens. Sufficient stone to fill the mold is soaked in water for 24 hours to saturate it so that water will not be absorbed from the grout.

Sufficient grout is made up of a mixture of equal parts by weight of Portland cement and a good grade of sand, screened through a 20-mesh sieve, with about 35 per cent. of water added, for the 6-in. cylinder specimens, and of neat cement with about 45 per cent. of water added for the 2-in. cubes.

The wet stones are mixed in with the grout until they are thoroughly coated. The mixed stone and grout are poured on a ¼-in. sieve and the surplus grout allowed to drain off. The stones, coated with grout, are placed in the mold and are packed down well, shaken while being put in place, so that they are in close contact with one another.

The remainder of the grout is well stirred up and poured into the mold near one side, jarring the mold continually so that all the voids between stones will be filled. The top of the specimen is finished smooth by adding grout and by slight troweling after the cement has begun to harden a little.

The 6-in. specimens are stored in a damp closet until broken at the ages of 14 and 28 days, while the 2-in. cubes are stored in water. The specimens are faced with a thin layer of plaster of Paris a few hours before crushing.

Fig. 1 shows graphically the results of the tests. It will be noted that several stones tested ranged over wide limits. The points plotted represent averages of from one to four specimens.

Other tests of a similar nature are under way at the present time, the primary object being to acquire a most suitable method, to be used as a standard for testing these materials.

CONSIDERATIONS AFFECTING THE DESIGN OF REINFORCED CONCRETE COLUMNS.

SEVERAL considerations affecting the design of reinforced concrete columns were presented by Mr. Ernest McCullough at a meeting of the Western Society of Civil Engineers in February last. His chief object in so doing lay in the hope of creating a discussion that would bring out some new data on the subject. The existing literature pertaining to the design of reinforced concrete columns was summed up by the author, whereupon he presented the following questions and opinions:

(1) What is the cross-sectional area of a reinforced concrete column? Commercial designers, almost to a man, use the cross-sectional area of the column complete. Others omit a skin ½ in. thick over the entire surface, but place the steel at least three times that distance from the surface, for fire protection. Others count none of the concrete as effective that is not enclosed within the upright reinforcement. Some building ordinances are so worded that any one of these assumptions may be used.

(2) What is the maximum compressive stress advisable on a column? Experiments have shown that no evidence of flexure appears in columns having a diameter less than one-twentieth the length, but neglect to say whether the diameter is gross or net. Few ordinances permit a reinforced concrete column to be erected with a length exceeding twelve times the diameter, again omitting to state whether the gross or net diameter is meant. Granting that no bending occurs, what should be the maximum stress? Commercial designers almost to a man use 750 lbs. per square inch on the gross section.

(3) Should the vertically reinforced column be used? American experiments seemed to indicate in one or two instances that horizontal ties around vertical rods were of no greater value to prevent buckling than the tensional strength of the concrete. American practice in the design of such columns proceeds upon the theory that such ties are for the sole purpose of assisting in prevent-

ing buckling of the reinforcement. If the Joint Committee Report is correctly read such ties are not required for any other purpose than to hold the steel in place during construction.

European experience and experiments indicate that while such ties have a value to prevent buckling of the steel, a distinct gain is made in strength by their use which is contrary to the general belief in America. The French Commission found that the spacing of these ties and the size of the wire affected the ultimate resistance of the concrete so materially that a formula was prepared into which a letter representing the volume of steel in ties was introduced. The Royal Institution of British Architects adopted rules based on those of the French Commission. A development of the formula gradually leads to the Considère formula for hooped columns, wherein the strength of the column is based on the fact that steel placed spirally as a hooping is 2.4 times as effective as the same volume of steel placed vertically.

The concrete column with vertical reinforcement, with ties only, is at present under suspicion and a free discussion of its value is invited. If it should disappear, then the sooner we know this the better. There are thousands in use over the country designed with a stress of 750 lbs. per square inch over the gross horizontal section, and with small ties intended to serve no other purpose than to act as stiffeners to prevent the vertical steel from buckling.

(4) Hooped columns should have the amount of steel limited and where should the limit be set? To Considère is given the credit for developing this column and he advised the use of mild steel for hooping. Professor Withey, of the University of Wisconsin, found that the elastic limit of the steel hooping was reached about the time the concrete was stressed to its ultimate strength, so he advised the use of steel having a high yield point. This seems logical, since the only reason for hooping is that it adds to the ultimate strength of the concrete.

(5) Are hooped columns dangerous from the standpoint of fire risk, when their strength depends upon the hooping?

(6) Are the present methods of fixing the pitch of the hooping adequate? The writer proposes a pitch of one-sixth the core diameter for columns having cores less than 18 ins. in diameter; one-eighth the core diameter for columns having cores from 18 to 24 ins. in diameter; one-tenth the core diameter for columns having cores more than 24 ins. in diameter; provided that the pitch shall in no case exceed 3 ins.

(7) The writer has seldom seen a design of a reinforced concrete building in which the effect of wind on the structure seemed to have been considered. Is this typical of reinforced concrete buildings and why?

(8) Some building ordinances state that unbalanced moments carried to columns must be provided for. How often is this done? The writer has not known of its being done, but there may be a few high-minded designers who do look out for this point. The writer proposes the following clause for all city ordinances: "For unbalanced moments carried into columns there shall be added to the load, for which the column is to be designed due to dead and live loads, the following percentages: To the columns supporting the roof, 30 per cent.; to the next lower tier, 25 per cent.; with a progressive reduction of 5 per cent. on each floor to 10 per cent. of the total load, which 10 per cent. shall be added on each floor thereafter to the first. This load shall not be counted in designing footings and shall be in addition to wind load. In addition to this increment wall columns to be designed for full live loads."

On this point of unbalanced moments, American text books are singularly silent.

(9) How should columns be carried up through buildings? It is convenient to have the steel rods one story in length and to place stubs at the floor levels for the purpose of delivering stress to the next section. Of what value are these stubs and how far should they extend above and below the floor level? Some engineers consider these stubs as nothing more than vertical pins, assisting to a slight degree perhaps in case of heavy winds. Other engineers proportion them on the assumption that the stress travels through the concrete to them from the steel on the floor above to that in the floor below. Has this assumption any basis in fact?

(10) Is it right to place the vertical steel in the concrete without providing plates at the lower end and caps over the upper end to distribute the load over a larger area of concrete than is provided by the end of the steel? The steel is assumed to be carrying throughout its length fifteen times the stress carried by an adjacent equal area of concrete, the bond stress throughout the length being constant. When the steel suddenly ends, with the concrete carrying its full load, what is the effect on the surrounding concrete when no attempt is made to transmit the stress directly through from end to end of steel, but on the contrary one bar may be some inches away from the parallel bar in the floor above, or below? Should there be plates at each floor and should there be plates in the footings? The writer recently examined plans prepared in the offices of engineers in high standing in which the lower ends of the column rods were hooked under the mat of steel in the footing. What is the general opinion of such practice?

MOTOR-DRIVEN STREET SPRINKLERS

That the trend of the times in the haulage field is toward the adoption of motor trucks in place of horse-drawn vehicles is a well recognized fact. For some reason private individuals and manufacturers have been quicker to see the advantages of trucks than have municipalities. This may come from the fact that business competition forces the adoption of every possible economy.

Municipalities are, however, susceptible to the economies involved and are taking up motor trucks in various departments, such as the collection of garbage and fire department.

The Tiffin Wagon Company, Tiffin, Ohio, have opened up a new field in the use of trucks by cities. They have brought out a new motor street sprinkler, and this will probably be followed by other motor-driven street cleaning equipment.

For this new vehicle they state that it distributes the water more evenly upon a street, that it covers practically twice the territory for each filling, and that it will cover three times the territory of the horse sprinkler in each working day.

It would seem within the province of all municipalities to encourage the use of motor vehicles in every possible way—both in their own service and at large. This is urgent. Sanitation demands that the horse be eventually dispensed with on public thoroughfares. Because of the capabilities of motor vehicles to negotiate better in crowded traffic, congestion, which is coming to be a serious problem in large cities, is to an extent relieved.

Editorial

ENGINEERS AND THEIR EMPLOYERS.

Canadian engineers, with the exception of a few, have much to learn in the art of arousing public interest in their work. Generally speaking, they do not appear to realize the value to themselves of a closer union with the public. This is so unfortunately true as to be detrimental to the value of their work when it is compared with activity in other walks of life, and it hinders an otherwise healthy development, in no small sense.

In some of the great undertakings of the country, the irrigation of vast tracts of land, the generation of electrical energy from natural water powers, the penetration of mountain ranges by our transcontinental lines, and even the bridges, buildings and canals under construction at the present time—their greatness is known to everyone, but not generally as the product of engineering. The part which the engineer plays in such undertakings is popularized in ways that are most elementary.

A study of industrial economics vindicates the prevalent impression that publicity is an important part of business, in that it provides the shortest route to the establishment of closer association between the producer and consumer, with the manufactured product as the medium.

In the case of the engineer there are a thousand and one problems confronting the public to which his services might well and satisfactorily be applied. There is no prejudice in the one against the other, but there is not that union which the exigencies of the case at hand frequently demand.

How much truth there is in the statement made a short time ago by a prominent engineer that the Canadian engineer's most powerful asset at the present time is a good business training! Undoubtedly the work of the engineer can scarcely be considered successful unless it is remunerative in some way. It is to render possible the transportation of a greater volume of traffic in a shorter time and under safer conditions, or, as in the case of water supply and sewerage schemes, it is to confer health and years of life upon many who otherwise would have their efficiency reduced by ill health or their lives prematurely terminated. In any case, the schemes with which the engineer has to do are schemes the main object of which is to facilitate business. In order that there may not be a misunderstanding that will produce unlooked-for and unfortunate results the engineer must be a man who can see things through the eyes of his employers so that the views of both may not divert one from another. This makes most desirable a closer intercourse between engineers and commercial men. The benefit to the engineer lies in his being better able to appreciate the scale of values that prevail in commerce and finance and at the same time to adapt his arguments in favor of a high efficiency to the point of view of the capitalist who does not always appreciate that the most expensive method may be the cheapest in the end. One sometimes encounters an opinion in the financial world that engineers are all right, providing the purse strings are held by someone else, that they are not to be trusted to do what they like, but must be kept under control by commercial men. In this respect the president of the Institution of Civil Engineers of Great Britain is quoted in "Engineering" of some months ago as having told a tale in one of his addresses of a great man in the financial world who said that of all the ways of wasting money the worst was giving it to engineers to spend.

Such an unfavorable feeling as this is not the result of a belief that the engineer has less ability than the financier, but that his education has not been sufficiently directed to the economic side of the questions which are presented to him.

COST OF STEEL MAKING IN THE ELECTRIC FURNACE.

According to Bulletin No. 67 of the United States Bureau of Mines, the cost of power for making steel in the electric furnace does not enter so largely into the final cost as it does in some other electrometal processes, especially the refining of molten steel. Plants are operating successfully under a power cost of 1 cent per kw.-hour in localities where material can be obtained at the price common to other processes. Plants such as the one at Ugine, France, have been established in remote localities, where the cost of power is but 0.2 cent per kw.-hour, but the cost of material is high.

For many years all high-grade steels were manufactured by the crucible process, but since the advent of the electric furnace there has been a gradual adoption of that furnace for refining steel. For the complete refining of the highest grades of steel the use of the electric furnace is now thoroughly established in Europe. Any product that can be made by the crucible process can be made by the electric furnace, and in most cases with cheaper raw materials and at a lower cost. In the electric furnace complex alloy steels can be made with precision. The high temperatures attainable facilitate the reactions and alloys need not be used so largely for the purpose of removing gas. Very low carbon steels can be kept fluid at the high temperatures. Steels free from impurities and of great value for electrical apparatus can be made. With the electric furnace large castings can be made from one furnace, whereas in the crucible process steel from several crucibles must be used. For small castings, which require a very high grade metal free from slags and oxides, electrically refined steel is especially adapted. The electric furnace gives a metal of low or high carbon content as desired, hot enough to pour into thin molds and still free from slags and gases.

There is now a tendency among consumers of rail and structural steel to require a higher-grade steel at an increased price rather than steel at a lower price. With the high cost of power that now prevails throughout the steel centres of the United States, the electric furnace can not compete profitably with either the acid Bessemer or the basic open-hearth process in manufacturing steel of like grade from pig iron. It is in combination with either of these processes that the electric furnace seems destined to be prominent in steel manufacture. The cost of super-refining in the electric furnace the molten steel from either of these processes, exclusive of the cost of the molten steel, varies from $1.50 to $2.25 per ton, depending on the cost of power and the impurities to be removed.

EXAMINATION OF CONCRETE FAILURES FOR THEIR DETERMINING CAUSES.*

By R. S. Greenman.

CONCRETE is said to be its own best inspector, and it is a well-known fact that defects in concrete will sooner or later make their presence known. For every fault there must be a reason. The reasons for poor concrete have been proportioned as being 90 per cent. due to poor workmanship, 8 per cent. due to poor aggregates, and 2 per cent. to poor cement. These percentages are not the result of tabulations, but are those prevailing in the minds of many who have had considerable opportunity for inspection of concrete, both good and bad. But whether or not these percentages are correct, the statement raises the question, "What are the reasons for poor concrete and how do we determine these reasons?" It is a certainty that neither a laboratory test nor a field inspection alone will give them, unless, of course, it be a simple failure. Yet there are people who will examine a piece of concrete in the laboratory and offer a solution of the problem simply by tests made there. And again, an inspector will look over a piece of concrete construction and with no knowledge whatever of the characteristics of the materials used, nor of the method of making, will attempt to tell how such and such a condition developed. Concrete failures can only be explained after thorough investigation by men who know good or bad concrete from long and close acquaintance, and whose minds are of an analytical and judicial temperament.

The more one sees of concrete the more one becomes convinced that it is the most abused structural material being used. The science of making concrete has been looked upon too generally as being very easily learned, with the natural result that a great deal of poor concrete has been made. Now, however, builders, contractors and engineers apparently desire to make concrete that will meet the standard in quality required of other materials, and yet, with all the precautions now being taken, there is still a large amount of concrete that is not satisfactory. The larger the work the greater the care taken; and, vice versâ, the smaller the work the greater the carelessness and the greater is the ratio of the failures, and it is the sum total of these failures that makes the loss caused by poor concrete so great.

In trying to solve a problem of poor concrete the elements to be investigated are the three already mentioned —cement, aggregates and workmanship—and water. The common tendency is to first place the blame upon the cement, but if we find that in accordance with good and generally common practice, the cement has been tested and has met the standard requirements, the cement then becomes a negligible factor; but if it has not been tested, it must be considered as a possible cause, and it may become a large item in the study. We must admit that since so much stress has been laid upon the value of having cement tested before use, and since it must indeed be a small work where it has not been so tested, the percentage of failures due to poor cement has been reduced to a very small amount.

If the next element has been given equally as thoughtful consideration previous to its use, there could not be so much poor concrete due to poor aggregates. The strong and weak points in both the coarse and fine aggregates have been too often neglected The coarse aggregates can usually be judged by easy inspections, but sand or other fine aggregates need very careful examination. Its characteristics—such as the grain, the grading, the cleanness, and its freedom from organic impurities and excess of loam—are items of knowledge which are obtainable mainly in the laboratory, but which are very essential for the correct diagnosis of a concrete failure.

The effect of workmanship is by far the largest factor, and in it all others are included, for a poor workman can destroy the value of the best materials. Under the head of workmanship must be considered such items as design, proportions, placing, and actions resulting from heat, frost, electrolysis, etc., which should have been taken care of during the process of making, hardening and preservation.

As another element of importance, it must always be kept in mind that the water used in making the concrete, or which may come in contact with it, may prove to be a very influential factor for harmful results.

Then, if one is given a concrete failure to diagnose one must look for a reason under cement, aggregate, workmanship and water. As stated, the easiest explanation is to look for some fault in the cement, but is, as has been suggested, the cement had passed the usual tests, then other reasons must be found. To find them requires that the investigator shall first know conditions and causes of failures, but these will not be further discussed except to point out the way to the reason; then the investigator must attack the problem with an open mind—that is, he must not jump at a conclusion and expect to be able to work out an explanation around that conclusion. Then it is even more essential that the investigator shall have had an opportunity to learn of results of tests, or to make tests that will enable him to judge the probable actions from the characteristics of the aggregates. Also, a very careful examination of the concrete in place is generally an absolute necessity.

To attempt to outline a plan for procedure in this examination would be folly, since each individual case has conditions that are decidedly its own, and the law of probabilities makes possible many combinations of causes which can only be worked out as one would solve any involved research problem. Clues must be sought, and a sharp eye, a quick ear, and a questioning tongue must be alert to grasp a clue and pursue it to a definite ending. If any one should be skeptical of the efficiency of this method, it is possible that a few illustrative cases, selected from a large number of diagnoses, may convince that one that the method has proven and can prove successful, far more than is generally expected.

Failure Due to Water.—A highway was being built and the plans called for several new concrete culverts. All but one of these culverts "set up," or hardened nicely. This one did not, and yet the same cement, sand and stone had been used as in all the other culverts. A reason for the failure of the one culvert was desired.

It was found that the brook which flowed through this particular culvert passed in its course the plant of a company engaged in the manufacture of medicine from herbs. The refuse from the plant so loaded the water with organic matter that it prevented a proper hardening of the concrete. No one connected with the construction of the culvert knew that water so contaminated would have that effect, and the complaint came in that the cement was not acting properly. The brook was temporarily diverted, other water was used and the concrete acted normally. A condition had existed there which would not have existed in city water, but which is found fre-

*Abstract of paper read before the American Society for Testing Materials, June 30-July 3, 1914.

quently in the country, especially in wooded sections. To detect the cause one had to know that certain elements, such as tannic acid, alkali salts, etc., foreign to most waters, do affect concrete.

Failure Due to Sand.—For an illustration of the effect of a poor quality of sand, consider the following case:

A cry of alarm came in from an engineer that the concrete in an important bridge abutment had been in place for over two weeks, and that in attempting to remove the forms it was found that the concrete was still so soft that it could be cut out with a knife. A brand of cement new to the work had been used, and the blame was, of course, placed on it. An examination showed that a footing for the abutment had been made of the brand of cement first used on the work and that, although ten days older, the concrete could easily be cut with a knife. The evidence eliminated the cement.

Examination of the sand showed it to be a well-graded, sharp sand, but a clue was furnished by some yellow-coated grains. The investigator had already had considerable experience with similar sand grains. A trip to the sand bank showed just what he expected to find. The bank had not been stripped of a top layer of yellow-coated sand, which gives a sand with which it is mixed a tendency to very materially delay the hardening of the concrete in which it is used. In time, usually several months, the concrete will harden and there is ultimately no harmful effect apparent. Lack of knowledge of this peculiar quality has caused an investigator of another piece of work to tear it out and rebuild.

Failure Due to Stone.—A very unusual condition existed in another case, but it emphasizes strongly the need of following clues. A concrete wall was apparently disintegrating due, as the engineers believed, to free lime in the cement. In various places on the face of this wall there appeared what can best be described as "blisters." By prying off these blisters there were produced small cones about 6 in. in diameter and 3 in. in height and in the apex of each could be seen a small, yellowish-white spot about the size of a small marble. The trouble was clearly not a case of free lime in the cement. One unusually large blister enabled the author to dig out from the apex a soft stone about 1½ in. in size. This stone did indicate the presence of free lime, and after a few weeks on the author's desk slaked into a powder. Examination of the stone composing the coarse aggregate soon brought out the following:

The crushed stone all came from the same quarry, but some came by a steam railroad and some by an electric railway. No concrete made by the former showed blisters. Concrete made from stone delivered by trolley did, but why? It seems that in the course of transportation by the trolley route, the stone was conveyed in waste dump-cars, across the grounds of the company owning the quarry and conducting a plant in which limestone is an essential raw material. These dump-cars had not been cleaned carefully, and to the good stone were added some small quantities of stone that had been through a chemical process and were on the verge of disintegration. In the concrete their expansive force blistered the face. By forbidding further deliveries by trolley the trouble was stopped.

These may be considered extraordinary cases, but it is the out-of-the-ordinary that makes trouble; if they were not the extraordinary they would probably have been guarded against. They are, at least, typical of points for which one must look if one would explain failures in concrete.

Failure Due to Workmanship.—Failures due to poor workmanship are seen so often that instead of citing particular cases it will be sufficient to briefly note some causes or results.

Failures from faulty design are shown in the mode of failure. The lack of proper proportioning may be clearly seen in a fractured surface; the grading of the aggregates is also similarly noted; and poor mixing and improperly placed concrete readily show themselves. All these are evident to an eye trained to know good or bad concrete. The failure to take care of laitance is made apparent by the seams that are bound to result from such a failure.

A concrete may be dense but not sound and hard, and "sounding" with a hammer will show up this characteristic. Too wet a mixture with fine sand or silt, or a crusher dust used as fine aggregate, may be a cause. It may be sound and hard and yet may be poor for certain uses because it is too porous. By scratching the face of unbroken concrete with a dull instrument, one may sometimes judge of proportions used and, in its early stage, can also judge somewhat as to the rate of hardening. A pocket glass in the field and a microscope in the laboratory help materially in determining the density, and in approximately the ratio of cement and fine aggregate to the coarse aggregates. The naked eye is all that is needed to observe concrete spoiled by sweepings of sawdust, shavings or blocks, or by waste carelessly dropped into a form. Lack of protection to fresh concrete from the sun or unusual heat may be noted by a "dried-out" and rapidly dusting surface, and from frost by a flaked and scaly surface.

Influence of External Forces.—Where concrete has apparently been good for a considerable period and has then begun to disintegrate, the reason for the failure must be sought in the character of the disintegration, whether it may be due to changes in the elements making up the concrete or to some external elements or forces that have entered into it. If due to an internal influence alone the fact will be noticed by the granular breaking up on the concrete. If due to an external force, such forces as sea water, alkali salts or electrolysis will be under suspicion as being responsible if the concrete has been under the influence of any of them. For many years all the failures of concrete were considered as being due to the formation of certain chemical relations; but as it is commonly acknowledged at present that an impermeable concrete will stand in sea water as well as elsewhere, although subjected frequently to more severe actions than other concrete, its failures are due frequently to the same causes as those of other concrete and therefore the same examinations should give the same results. Similarly, since electrolysis is considered as a cause for the breaking down of concrete, the liability of concrete being affected by its influence will depend upon whether the concrete comes under the influence of an electric current. If it does, then its influence needs to be examined. If it does not, then the examination should also follow the usual method.

The value of laboratory tests and analyses should not be overlooked. While perhaps not giving as definite information as a field inspection, they should be used to the fullest extent to help establish the strength or weakness of a reasonable theory for the cause of failure. Where time will permit, laboratory tests of concrete made of the aggregates under as nearly as possible the same conditions, will give results that should aid in determining the fault in the original. Test specimens so made and treated should give practically the same results, and when compared with test specimens made under ideal conditions or

with standard materials, should give the investigator the reasons for the failure.

All means possible should be used by an investigator in making his examination, and his conclusions must be drawn only after he has considered the failure from every probable cause with reason and fairness. The object of the examination is either to place responsibility or to guard against future failures, and right conclusions are the only ones that should be drawn if justice to either objective is to be given.

Coast to Coast

London, Ont.—Six miles are to be added to London's paved street area this year, bringing the total up to 15 miles out of a total of 136 miles of streets.

Galt, Ont.—The installation of the 18-inch water main, the largest contract ever undertaken by the waterworks department of Galt, has been completed.

Sarnia, Ont.—It is rumored at Sarnia that a company of men, mostly of Sarnia and Petrolea, will commence very shortly drilling for gas on the Indian reserve close to Sarnia.

Hull, Que.—A loan of $50,000 to Hull has been received from the provincial bank; and the city is commencing at once to carry out certain local improvements, principally to roads and sidewalks.

Calgary, Alta.—Difficulty is still being experienced at Calgary in the matter of effecting an agreement between the city and Mr. Eugene Coste regarding the supply of natural gas to Calgary.

Irma, Alta.—A report of a further oil strike has been circulated from Edmonton. A small flow was encountered at a depth of 85 feet near Irma, which lies 10 miles east of Edmonton on the G.T.R.

St. Catharines, Ont.—Considerable difficulty is being experienced in reaching an agreement concerning the liability of cost of a pure water supply pipe line from Lake Erie to the towns along the Welland Canal.

Galt, Ont.—A well-grounded rumor is being circulated at Galt to the effect that negotiations are in progress to secure a site for a Union Station for Galt, to be used by the C.P.R., G.T.R., and Lake Erie and Northern Railways.

Fenelon Falls, Ont.—The Seymour Power Company has completed the construction of its new dam at Fenelon Falls. The plant is capable of developing about 1,500 horsepower, and is to serve the purpose of a reserve supply.

Winnipeg, Man.—Construction work commenced on July 8 on the new drill hall in the northwestern portion of Winnipeg city. The building will cost $110,000; and the contract is held by the Brown Construction Company, Limited.

Moncton, N.B.—A gas sand has been struck by the Maritime Oilfields Company in the Albert County gas field, which it is stated is giving a flow of 2,000,000 cubic feet of gas per day. The discovery was made by the deepening of an old well.

Cobourg, Ont.—It is now stated that the Trent Valley Canal will be opened from Peterboro to the Bay of Quinte this fall; and that next spring a regular service will be established. The new section of the canal from Balsam Lake to Lake Simcoe will be deepened.

Woodstock, Ont.—An inspection of the work that has been done in Oxford county in connection with the good roads movement was made by Engineer Huber, of the provincial highways department. Satisfaction with the work has been expressed by the engineer.

Chatham, Ont.—Civil engineers in connection with the Good Roads Branch of the Ontario Department of Public Works are at Chatham making a survey of this section of the country with the object of making recommendations to the Ontario Government regarding plans for improving the roads.

St. Thomas, Ont.—The Hydro-Electric power line from St. Thomas to Windsor will be connected at West Lorne in the course of a few days. The necessary work at the St. Thomas sub-station is practically complete; and it is stated that Niagara power will be available for distribution in Windsor during August.

High River, Alta.—Oil has been found to exist in the well which has been drilled within the limits of High River for the purpose of supplying gas to that town; and the substance is said to be of similar character to that struck in the Dingman well near Calgary. The well at High River has not been drilled below 505 feet.

Assiniboia, Man.—Another oil strike rumor comes from Assiniboia, Man., where it is claimed that the fluid was found in a well being bored for water supply at a depth of 1,000 feet. The discovery was made about 17 miles west of the territory of Verwood, in which district claims are now being filed and further drilling operations commenced.

Toronto, Ont.—Direct connection has now been made between the North Toronto district and the large water supply plant at Yonge and Heath Streets, Toronto. The increased pressure for the supply of water for North Toronto gives 130 pounds per square inch in the mains instead of 50 pounds. The booster pump has a capacity of 750,000 gallons a day.

Fredericton, N.B.—Mr. F. P. Gutelius, general manager of the I.C.R., together with other officials of the railway company, has been making an inspection of the St. John Valley line from Fredericton to Gagetown, with a view to selecting a terminal site for a prospective divisional point. Some announcement is expected as to its location in the near future.

Wallaceburg, Ont.—A report from Wallaceburg advises that satisfactory progress is being made on the new waterworks plant being constructed at that point. Nearly half a mile of the ditching for the main intake from the Suye has been completed; and the pumping stations will be ready for machinery within a short time.

Swift Current, Sask.—The local government board at Regina has authorized an issue of debentures by the town of Swift Current to total $196,000 for the financing of necessary local improvements. Of this amount, one issue will be for sewer construction amounting to approximately $112,000; one for an electric lighting plant at $60,000; and a third to provide for concrete sidewalks totalling $15,000.

Kamloops, B.C.—The drill hall which is to be erected at Kamloops will be what is known as the "class D" building, or the type generally constructed in larger cities. The total length of the new building will be 199 feet; and the overall width 82 feet. The foundations will be built of concrete; and the building proper, of red brick. A considerable amount of structural steel will be used in the gallery surrounding the main hall and for the roof spans; while, in the basement will be located the furnace which controls the one pipe low-pressure steam circuit system, which is to be installed.

Ottawa, Ont.—The Federal Town Planning Commission is now engaged in making a comprehensive study of the question of the location and elevation of the bridges on the Rideau Canal. The report will not be ready until September. It is likely that a deputation will be sent from the city council to ask that the clearance space be allowed to be made only 10 feet instead of having to be 30

feet. This would allow the construction of numerous bridges and provide for the rapid development of the section of the city south and east of the canal, and would do away with the occasional large ship traffic into the centre of the city.

Victoria, B.C.—Recently, the laying of the steel pressure pipe for Sooke waterworks from Humpback reservoir to the city commenced at Manchester road, near the Gorge road, where the work done by the Westholme Lumber Company in 1912 ended. The contracting firm for this work is the Burrard Engineering Company of Vancouver. Pipe laying on the concrete flow line between Cooper's Cove and the lake is being rushed by the contractors, the Pacific Lock Joint Pipe Company, two shifts laying from the Humpback Reservoir end and two from the Sooke Lake end. About 400 or 500 feet of concrete and steel pipe will be laid daily by the gangs of the respective contractors, though the rate will be increased on the flow line by the additions to labor which are being made.

Hamilton, Ont.—The National Steel Car Company of Hamilton expects that by fall, it will be running to capacity day and night, so numerous and promising are the recent orders for rolling stock for which the firm has taken contracts. Also a considerable addition is to be constructed to the passenger car shop, owing to the large number of passenger cars on order with the company; and the contract for this work is in the hands of the Hamilton Bridge Company. The firm expects that, with this addition, it will be able to construct 30 passenger cars at a time, with a capacity of 150 per year. This will be in addition to the output of street railway cars. It is not expected that orders for freight cars will be heavy this year, though next spring is expected to bring with it a very active demand for this stock and equipment.

Victoria, B.C.—The grading of the Marine Depot site and construction of the wharf on the eastern shore of the Songhees Reserve has reached such a stage that the contractors, Messrs. Parks, Tupper and Kirkpatrick, expect that the work will be completed by the end of this month. The excavation is about three-fifths complete, in spite of the fact that this section of the contract has been greatly retarded recently owing to the frequent encounter of solid rock. All the bearing piles of the wharf have been driven and capped, and the "L" portion of the wharf is floored, while practically all the joists are in position on the balance of the structure. The fender piles have yet to be driven after the flooring has been completed. The total length of the wharf will be 650 feet, running 424 feet north and south, and 225 feet inshore. By the time the contract is completed it is estimated that approximately 27,000 cubic yards of material will have been excavated and levelled off on a line with the wharf.

New Glasgow, N.S.—At the present time, the Canadian Provincial Power Company, recently incorporated in New Glasgow, N.S., is awaiting a report from a firm of Montreal engineers, specialists in power development, containing final figures and data in connection with the company's proposed power plant on the East River at Sheet Harbor. It is estimated that the entire cost of development and conveyance of power to towns concerned will be $1,500,000, and that the power lines of the company will cover a length of 42 miles in all in order to serve the towns of New Glasgow, Stellarton, Westville and Trenton. The company expects to have its lines completed and the power generating plant installed in about 18 months; though it is not intended that the development will stop with the towns named. Distribution lines may be carried later into Antigonish and Truro. Another feature of the proposition is that the distribution lines will run directly through the heart of the largest gold mining district in Nova Scotia; and the company expects that when its lines have been finally erected and the electrical power generated; then it will be able to give to these mining companies an abundance of power for the operation of mines at a very low figure.

Patricia Bay, B.C.—The wharf structure which has been announced recently to be constructed without delay at Union (Patricia) Bay by the C.N.P.R. company, will be of a temporary character; although it will be 40 feet long and 64 feet wide, or sufficiently large to accommodate the material which will be utilized in the final work necessary for completing for service the Patricia Bay branch of the railroad. It is to be capable of handling at low water a vessel drawing 24 feet, and to be ready for the shipments of rails, angle bars, bolts and spikes for 115 miles of road, which material is being obtained from the Dominion Steel Company of Cape Breton. The contract will stipulate that the work be completed within 90 days; and in that period, the first cargo, approximating 7,000 tons of steel, will be landed, and the final stage of construction will be initiated. Before the supplies are exhausted, another shipload will have arrived, which will permit the road to be finished to mileage 115. By the time this large section is ready for the inauguration of a regular service, plans will have been completed for the continuance of the line, for its Northern terminal. In connection with the latter point, it is stated that Sir Donald Mann is expected to visit Victoria this month with regard to the company's plans for railway development on the Island.

Edmonton, Alta.—Local reports state that over $10,000,000 will be expended by the C.N.R. in Alberta in 1914. Included in this amount is the $6,500,000 for the construction of the Canadian Northern Western, a subsidiary company to the C.N.R. The amount of work to be done includes the mileage from Onoway west to Pine River Pass, or what is generally supposed to be the main line of the Canadian Northern Railway to the Peace River country. Grading has been completed as far as Whitecourt; and 32 miles of steel have been laid. The rest will be laid this summer. The program includes also the line from Oliver northeast to St. Paul de Metis. This line is guaranteed for 100 miles at $13,000 per mile. Although some of the grading has been completed on this line, no steel has yet been laid. There is the road from Bruderheim by way of Vermilion, Wainwright and Medicine Hat to the boundary with the branch northwest of Vermilion to the eastern boundary. This line has been guaranteed at $13,000 per mile for a distance of 30 miles. Other sections are: Calgary northeast to Brazeau line, which leaves the Calgary-Edmonton line near Calgary; Camrose to Alsask from Camrose to the Saskatoon-Calgary section; Edmonton to Pincher Creek; Blackfalds to Goose Lake. Work has been done on some of these lines and an effort will be made to complete them as early as possible.

PROGRESS OF THE GRAND TRUNK PACIFIC RAILWAY.

Confidence is expressed by Mr. Collingwood Schrieber, general consulting engineer to the Dominion Government, and chief Government engineer inspecting the Western divisions of the Grand Trunk Pacific Railway, that the new transcontinental will be ready for through service this autumn. He claims that the new transcontinental is in excellent condition between Winnipeg and Edmonton, in very fair shape between Edmonton and McBride, and is rapidly being placed in first-class order on the other sections. The G.T.P. is operating regular express trains as far as McBride, 342 miles west of Edmonton, and service trains between that point and Fort George, 144 miles further on. From Prince Rupert, the company is running trains as far east as Priestley, 337 miles east of the Pacific terminal. Ballasting is now rapidly approach-

ing completion on the intervening portion of the line, a distance of about 140 miles. No definite date has yet been set for the opening of through service; but the road is expected to be in good running condition by the middle of August. There is still a considerable amount of ballasting to be done between Prince George and Priestley, but rapid progress is being made with the work.

TORONTO BRANCH CANADIAN SOCIETY OF CIVIL ENGINEERS.

The executive committee of the Toronto branch of the Canadian Society of Civil Engineers has made arrangements for the following accommodation in the new Engineers' Club:

(1) A room for a joint technical library to which members of the societies to which the books belong shall have access.

(2) A small room adjoining the library for the exclusive use of members of the branch.

(3) A lecture room capable of seating one hundred persons.

A library committee of the branch, which has been at work since last January, is building up what should be a useful working library for engineers. While first consideration has been given to series of transactions and proceedings of important engineering societies, a considerable number of books are being added, this summer, to those already on the shelves. It is hoped to have the new additions completely bound, catalogued and ready for use by October 1st in order to extend the privileges of the library to those student members at the University, who desire to use them.

The following companies have kindly consented to allow the members of the branch to visit their works from time to time. Any member or group of members wishing to avail themselves of this opportunity are requested to obtain a card of introduction from the secretary of the branch: Canada Foundry Company, Limited, Toronto; Canadian Pacific Railway Grade Separation, North Toronto; Department of Works, Toronto; Hamilton Bridge Works Company, Hamilton, Ont.; Polson Iron Works, Toronto; Steel Company of Canada, Toronto; Thor Iron Works, Toronto; Toronto Harbor Commissioners, Toronto, and Welland Ship Canal, St. Catharines, Ont.

The secretary, J. S. Galbraith, announces that a programme of the meetings to be held this autumn will be issued shortly.

The Manitoba Gazette announces the following provincial appointments in accordance with the Good Roads Act: Chief Engineer, M. A. Lyons.

Engineers, S. A. Button, T. T. Wilson, J. B. Philips, W. Youngman, R. Whitside and F. Minvelle.

Assistant Engineers, W. R. Bertram, L. Cote, and W. H. Bladock.

Inspector, H. T. Thornby.

Draughtsman, C. N. G. Milne.

BACK COPIES FOR DISPOSAL.

A subscriber, who has copies of *The Canadian Engineer* practically complete from Volume 6 to date inclusive, and who, for certain reasons is anxious to dispose of them, would like to hear from readers who may be interested in the matter Address, in the first instance, James J. Salmond, Managing Director, Canadian Engineer.

PERSONAL.

ROSS H. McMASTER, Montreal, has become a director of the Steel Company of Canada, succeeding in that capacity the late Senator Gibson.

RALPH MODJESKI, Consulting Engineer, Chicago, and a member of the Board of Engineers of the Quebec Bridge, has been retained by the Burrard Inlet Tunnel and Bridge Company to report on the tenders which the company has received for the construction of the Second Narrows bridge, Vancouver. The structures will cost approximately $2,000,000.

W. P. DOBSON, B.A.Sc., has been appointed director of the experimental laboratories of the Hydro-Electric Power Commission of Ontario. The laboratories are located in Toronto. For the past eighteen months Mr. Dobson has been carrying on research work on electrical disturbances in high tension transmission systems, for the University of Toronto Engineering Alumni Association. The work has recently been completed and Mr. Dobson's results form a very valuable addition to the existing information respecting such phenomena as that produced by the switching of heavy loads of high voltage lines.

COMING MEETINGS.

UNION OF CANADIAN MUNICIPALITIES.—Annual Convention to be held in Sherbrooke, Que., August 3rd, 4th and 5th, 1914. Hon. Secretary, W. D. Lighthall, Westmount, Que. Assistant-Secretary, G. S. Wilson, 402 Coristine Building, Montreal.

WESTERN CANADA IRRIGATION ASSOCIATION.—Eighth Annual Meeting to be held at Penticton, B.C., on August 17, 18 and 19. Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

AMERICAN PEAT SOCIETY.—Eight Annual Meeting will be held in Duluth, Minn., on August 20th, 21st and 22nd, 1914. Secretary-Treasurer, Julius Bordollo, 17 Battery Place, New York, N.Y.

CANADIAN FORESTRY ASSOCIATION.—Annual Convention to be held in Halifax, N.S., September 1st to 4th, 1914. Secretary, James Lawler, Journal Building, Ottawa.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown, Indianapolis, Ind., Secretary.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.—11th Annual Convention; 5th American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau St., New York, N.Y.

The Mayor of Halifax, City Engineer and Controller Hobur will represent the city of Halifax at the Union of Canadian Municipalities to be held at Sherbrooke, Que., early in August.

Volume 27. Toronto, July 30, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

DEEP WATER TERMINALS AT HALIFAX

REINFORCED CONCRETE PIER CONSTRUCTION BY DOMINION GOVERNMENT FOR THE INTERCOLONIAL RAILWAY—DETAILS OF PILE CASTING AND DRIVING—OUTLINE OF ULTIMATE DEVELOPMENT.

By T. W. J. LYNCH, C.E.,
City Engineer's Staff, Halifax, N.S.

To such an unexpected extent has the volume of freight passing through the port of Halifax increased of recent years, that the Government Railways' Managing Board has been forced to map out a comprehensive plan of extension by which it is hoped and improvements will be constructed chiefly at Deep Water. Fig. 2, showing the old as well as the contemplated development, gives an idea of the vast improvements to be made at this shipping centre. The plan of improvements includes four piers sufficiently large to

Fig. 1.—View of Pier No. 2 While Under Construction

to care for the constantly increasing traffic on the Intercolonial Railway.

The city has two terminal points, one known locally as "Deep Water" and the other as Richmond. The Deep Water terminal is centrally located in the city proper, while the other piers are located at Richmond at the northeastern extremity of the city. The proposed extension accommodate steamers over 700 feet in length, considerably increasing in this respect the capacity of the terminal. One of these piers, No. 2, has been completed. New piers 3, 4 and 5, shown dotted, are as yet in prospect.

The old piers were all of a much smaller size. Old pier No. 2 was practically rebuilt 15 years ago, having a second story added 6 years ago. This was found in-

adequate for general purposes, as its south side was too short for long steamers and the basin in the north side was too narrow. Old pier No. 3, recently rebuilt, is still in good shape and will probably be included in the completed scheme.

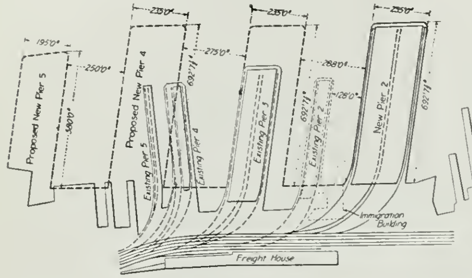


Fig. 2.—General Plan of Development—Existing Piers Shown Dotted.

When these terminals were finally decided upon, Mr. John Kennedy, Hon.M.Can.Soc.C.E., consulting engineer, Montreal, was retained upon the work, and it was under his direction that the contemplated plan was developed and is now being carried out. Mr. A. F. Dyer, C.E., is the resident engineer who is supervising the work, and his assistant is J. Shepherd Lee, C.E.

These improvements make provision for four new piers, pier 2 being 800 ft. by 235 ft., with freight and passenger shed. Pier 3 is for freight purposes only, having the same dimensions as No. 2, and being of similar construction. Pier 4 will also be 800 ft. by 235 ft. with accommodations similar to No. 2. Pier 5 will be 650 ft. by 190 ft. and will be used for smaller steamboat and sailing vessels, as well as for transatlantic steamships. The basin width between piers 2 and 3 will be 280 ft., between Nos. 3 and 4, 275 ft., and between Nos. 4 and 5, 250 ft. These basins will be dredged to a minimum depth of 34 ft. below mean low tide.

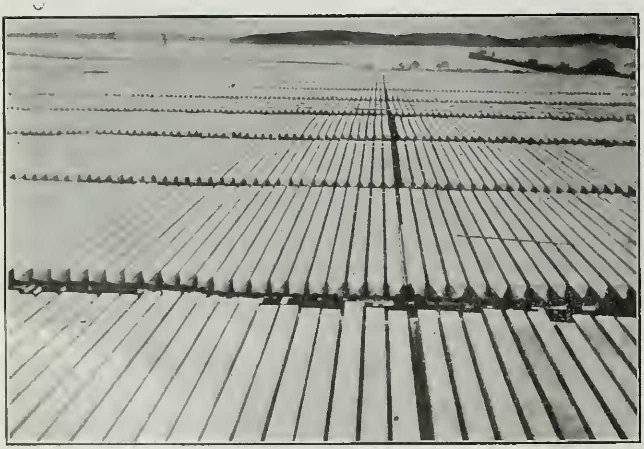


Fig. 4.—View of Pile Casting Yard.

Pier 2 is the first to be constructed and is now complete, the Nova Scotia Construction Company having had the contract at $914,600. This pier is located between the old Immigration Building and the Cunard pier, the latter interfering to a great extent, and now being completely removed.

It was decided, owing to congested yard space, to build a new bulkhead further out in the location indicated. The cribwork of this new bulkhead is to be built in blocks reaching up to about 2 ft. above low water. Above this point the cribwork is to be continuous. The facing of this cribwork is to be of squared timber and made mud-tight. The top of the bulkhead will be finished off with a coping of squared creosoted pine timbers. All timbers over 3 ft. above low water are to be creosoted, the proportions being 12 lbs. of creosote per cubic foot of timber, except for planking, in which case the amount will be increased to 18 lbs.

To strengthen the immigration building wharf where the facing is exposed, sheet piling of squared timber has to be driven along the face and for a distance of 30 ft. beyond the corner. For a further distance of 25 ft. the foundation and cribbing will be protected by round piling. Most of this square sheet piling is to be creosoted, and is to be driven 39 ft.

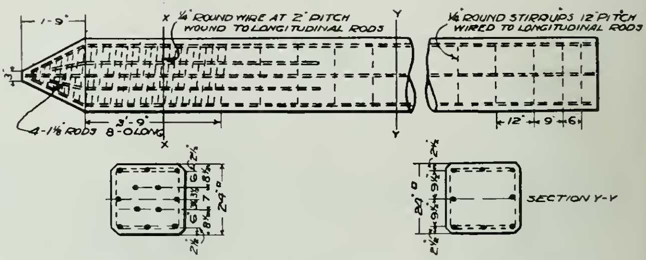


Fig. 3.—Details of Reinforcement of Concrete Piles.

On account of the great depth of water and unevenness of the bottom, there was some difficulty at first as to the mode of construction. The bottom is formed of a substructure of rock, the stratum running nearly perpendicular and presenting a very rough and uneven surface. The rock is covered by a bed of gravel and hardpan varying from 4 ft. to 12 ft. in thickness. This is in turn superimposed by a layer of mud 5 ft. to 25 ft. thick. At the outer end the rock depth is 67 ft., and in shore 44 ft.

Owing to the enormous weight which the supporting piles would be required to carry and owing also to the activity of teredos and limnoria at this point, the use of wooden piles did not meet with favorable consideration, and reinforced concrete piling was adopted instead. The piles are of the construction and size denoted in Fig. 3.

For piles over 70 ft. long the longitudinal reinforcing rods are 1 1/4-in. rounds; between 60 and 70 ft., 1 1/8-in. rounds; and under 60 ft., 1-in. rounds. Four extra 1 1/8-in. longitudinal rods extend up for a short distance from the pointed end. Except near the point of the pile, where the rods are wound with 1/4-in. round wire at a 2-in. pitch, the rods have 1/4-in. wire stirrups, at

a 12-in. spacing. The largest of the piles weigh about 25 tons. The concrete is composed of 1 of cement to 4½ of aggregate, the latter being composed of about 1½ of sand to 3 of broken stone. The cement used was specially selected to resist frost and salt water action, the former causing spalling of the concrete between tide levels and the latter setting up a chemical action with the constituents of the cement causing disintegration. The selected brand has an extremely low percentage of alumina, the specifications calling for a maximum of 6.3%. Used in the proportions mentioned above and carefully graded, a dense and impermeable concrete is produced. To further protect it against frost action between high and low tide levels, the pile is sheathed over a space of 8 ft.

Each pile was made with one filling of the mold, and the concrete thoroughly rammed into place, more particularly at the water line. Fig. 4 gives a view of the pile fabricating yard, which is 600 x 800 ft. in dimensions. The piles, which are 24 in. square, were set in the molds for 7 days at least and were not lifted for 6 weeks or driven in less than 8 weeks. The estimated maximum load to which each pile will be subjected when in use is between 85 and 86 tons, and in order to safely sustain this weight, they are all being driven through the hard-pan to solid rock, steam hammer and water jet being used for the purpose. A floating weight of 180,000 lbs. which, at low tide, will apply itself to the pile under test, is one of the means suggested for testing the bearing power.

The average height of the structure, from solid rock to the level of the tracks on the pier, is 75 ft. Extreme low-water level is 15 ft. 8 in. below track level. Because of the fact that such a difference exists between the distances above and below water through which the piles were to extend the pier was stiffened by reinforced concrete brace piles driven as shown in Fig. 3. This system of bracing is novel and, according to several authorities, this is its first application. As shown in the diagram, three vertical piles and one brace pile support each interior column, while three singly driven intermediate piles carry the floor.

In order to handle these 1,800 extremely heavy piles and to drive them through the hard-pan to solid rock a special pile driver was constructed by the Bucyrus Company, of South Milwaukee, Wis., under the direction of Mr. W. L. Scott, chief engineer of Mussens, Limited, Montreal, who was retained by the contractors in the matter of designing a suitable machine. It is of massive construction, the machinery on account of the weight of the piles being very heavy. The gearing is all of cast steel with cut teeth, and the drums steel castings bronze bushed. The hull is of wood, 108 ft. long, 45 ft. wide and 12 ft. deep at the bow. In order to support the leader carriage tracks, solid timber bulkheads run fore and aft. These, in addition to several transverse trusses, provide a hull of extremely rigid construction.

To facilitate the driving of brace piles without changing the position of the driver, the leads are designed so as to have a transverse motion of 8 ft. across the face of the hull, and a fore-and-aft motion of 7 ft., and a transverse sloping position to an angle of at least 20°, sufficient in all to encompass the driving of a whole cluster of piles without moving the pile driver hull from the position to which it is fixed by the spuds.

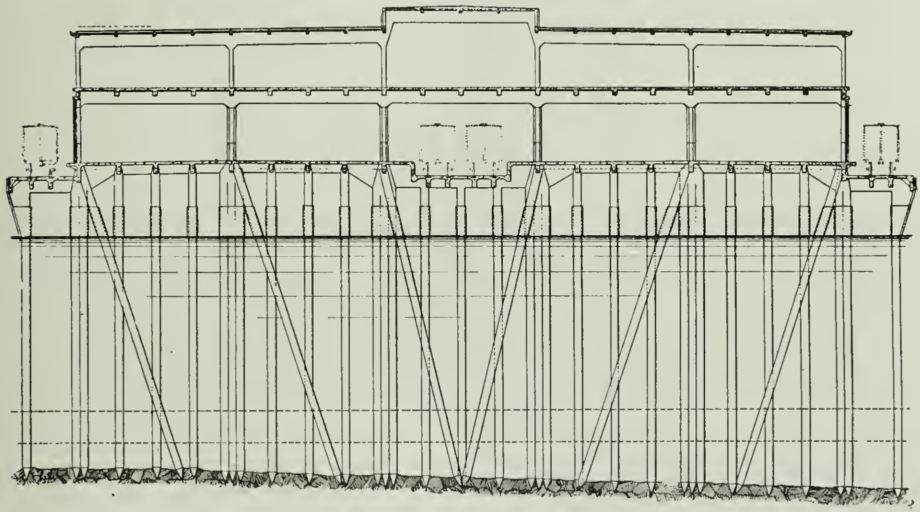


Fig. 5.—Transverse Half-Section of Pier, Showing Arrangement of Brace Piles.

The drums and machinery for hoisting the piles and the hammer and for operating the stern spud are driven by a double-cylinder 12 x 16-in. engine. All this machinery is mounted on a heavy structural-steel carriage, so arranged as to be moved fore and aft. This carriage is in turn mounted on rollers which travel fore and aft on a suitable track. The whole is moved by means of a rack-and-pinion drive from the main engine, the rack being rigidly bolted to the deck. The front of the carriage is provided with two transverse heavy structural-steel girders, one just above the deck level and the other some 30 ft. higher, running across the leads. These two transverse girders are shown in Fig. 6. The upper girder carries a trunnion bearing which supports the weight of the leads.

The lower carries a specially designed crosshead, attached to the leads in such a way that they are held vertically in any position.

The trunnion bearing on the upper girder and the crosshead on the lower girder, are both connected to independent screw shafts driven by 8 x 8-in. double-cylinder engines. When both screws are in gear with the engines, the leaders can be moved transversely across the leader carriage and battered to any angle. In order to batter the leaders it is only necessary to drive the upper or the lower screw alone. The advantage of this screw design is to make the mechanism fool-proof, as no false motion on the part of the operator can turn the leaders over. The forward spuds hold the driver in position when in action. Each spud is provided with an independent spud-handling engine, which raises the spud or "pins up" the driver as is the practice on a modern dipper dredge.

3 feet beyond the end of the piles, the hammer is fitted with a special cap. The leads are provided with a special hammer track, by means of which the hammer when hoisted can be switched in out of the way of a swinging pile. An automatic dog locking device is also provided at the top of the leaders to carry the weight of the hammer while the pile is being placed in position, and also an intermediate stop to hold the hammer when the driver is not in use. The main engine, drums and machinery weigh approximately 33 tons, the leaders 40 tons, the leader carriage 40 tons and the steam hammer 15 tons. The machine was originally intended to drive one pile an hour but it has been found that it can, with ease, handle 20 to 25 in a 10-hour working day.

The character of the material through which the pile is being driven controls the capacity considerably, as it takes from 25 to 30 blows of the hammer to drive the pile

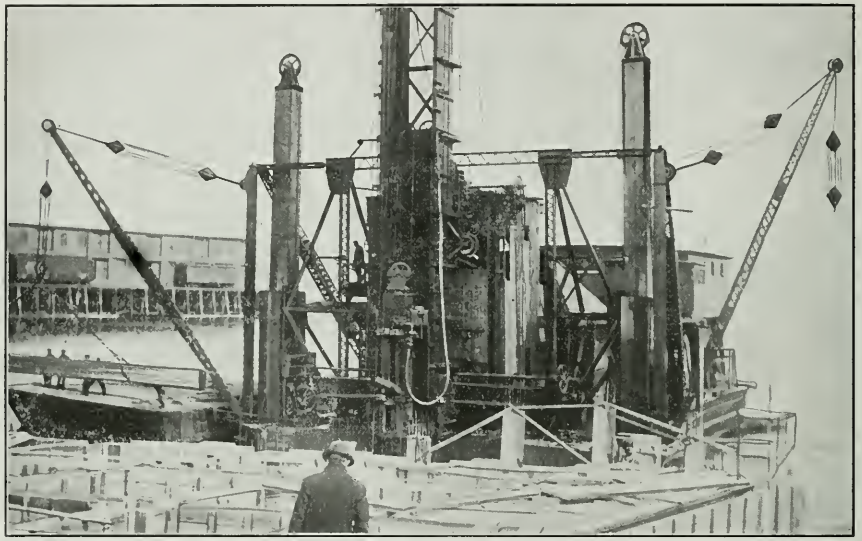


Fig. 6.—General View of Pile Driver and Top of Form Work.

one inch into the hard-pan which is encountered. In actual practice, however, it has only been necessary to drive about 15 piles a day.

Figs. 7 and 8 show the driver with the leads canted and brace pile being driven.

The piles were delivered to the driver loaded on scows. Two derricks were provided for lifting them and swinging them in front of the leads. These derricks were placed one on either side of the driver on the deck and outside of the forward spud guides. The swinging of the derrick was accomplished by manipulating the forward spuds. The pile cable being made fast to the staple projecting from the pile head, the order to hoist was given, and as the derrick fall was lowered the pile was gradually hoisted into a vertical position, the derrick straps being disengaged as they slackened off. The leaders are then moved until the pile, hanging in them, was centered in exact position. Then the pile was lowered, its own weight being sufficient to penetrate the soft mud overlying the hard-pan. When the thickness of the mud was equal to about a third of the length of the pile it was

The spud machinery is placed well aft on the deck and is connected to the spuds by wire ropes leading over the top and bottom of each spud. The levers controlling the movements of the spud engines, are so arranged that the engineer from his position in the traveling leader carriage has full control.

The steam hammer which was designed and built by the Union Iron Works, of Hoboken, N.J., is without question the largest double acting steam pile driving hammer ever constructed. The combined weight of the hammer with follower and follower guide is approximately 28,000 pounds. The diameter of the cylinder is 14 in., stroke 36 in., and the weight of ram alone is 4,000 pounds. With a mean effective steam pressure in cylinder of 80 pounds per square inch, the hammer is rated to develop 3,916,000 foot pounds per minute, when the hammer is striking 80 blows per minute. With a penetration of pile of one inch for each blow, the average force of the blow would be 588,000 pounds. This assumes that the steam follows the piston during the entire stroke. In order to take care of reinforcing bars, which project

found that the pile would stand where placed without any bracing; as a rule, however, the pile was braced while the hammer was being adjusted on its head.

Separate cushions were used between the concrete of the pile and the ram of the hammer. On top of the pile was placed a 3-in. spruce plank. On this rested a cast-steel follower about 4 ft. high consisting of a hollow cylinder or post with top and bottom flanges. The bottom flange was flat, and in it were eight holes through which the projecting rods of the pile reinforcement passed and were protected. The top flange had cast on its upper side a rectangular depression in which was placed a hardwood block about 15 in. thick, bound round with a steel band. This block received the direct blows of the hammer and had to be frequently renewed; sometimes it would last for two piles only, while at other times it would stand the hammering of twenty. Usually the cause of failure was the breaking of the steel bands, but on one occasion the block was found to be on fire and badly charred owing to the heat generated by the force of the blows.

Where the thickness of hardpan was small the pile would often come to a stop after 200 or 300 strokes, while at other places nearly 1,800 blows would be required. The rate of penetration through the hardpan was small, the advance in the last strip being in many cases not more than ¼ in. per blow.

Only two out of 1,550 piles had their heads smashed in driving, and these were among the first dozen driven, the cause being a continuation of the hammering after the pile had reached rock. No harm was done, however, by a few blows after the penetration had stopped. In order to find out what was happening to the point of the piles some of them were pulled out after having been driven to refusal. In only one case was there any damage done to the point, and this damage is believed to have been caused by a projecting rock spalling off a small amount of the concrete.

The bearing power of the piles was tested after driving by one of them being subjected for 3 hours to a load of 120 tons. This caused no settlement whatever.

It is the intention to have two railway tracks extending the length of the pier through the centre of the shed, and two outside, one on each side. The flooring is raised to the car deck level above the tracks to facilitate and expedite the handling of freight. There are two roadway ramps at the Water Street end, one on each side, for the accommodation of dray traffic.

Superstructure on Pier.—The shed will consist of fireproof material having reinforced concrete walls and floors. It is necessarily of substantial construction as upwards of 3,000 immigrants and their effects will be housed in the building when two large well-filled steamships reach port at the same time. The building is a two-story structure. The ground floor is a plain floor for freight purposes, covering the whole area of the building with a series of railway, steamship and custom offices and storerooms at the shore end and in each side of the two central freight tracks. Along each wall, outside of which are the exterior tracks above referred to, there is a series of overlapping doors of sheeted steel frame construction. These can be slid along to form an opening at any desired place in the full length of the building. The upper story of the building is for passenger purposes exclusively. It is divided into three main sections, baggage rooms on the north and south extending the full length, with the exception of a distance of about 100 ft. at each end, and passenger rooms and offices along the whole length of the central part of the shed and across the whole width of each end. The outer wall of each baggage room will have alternate doors and windows at 36 door centres, so that it may receive passengers and baggage from any part of either two short or one long steamer up to the full length of the pier.

The adoption of the plans for the Deep Water terminal improvements means a general shifting of the railway yard arrangements. Other equally extensive changes will likely be necessitated to bring about a completely harmonious arrangement.

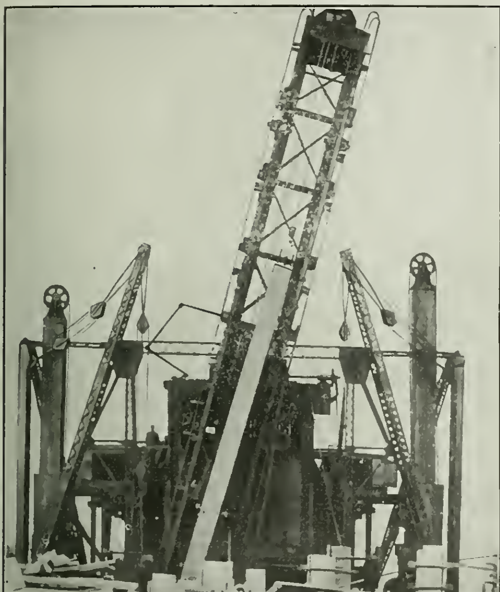


Fig. 7.—Leads of Driver Canted With Brace Pile Ready for Lowering into Position.

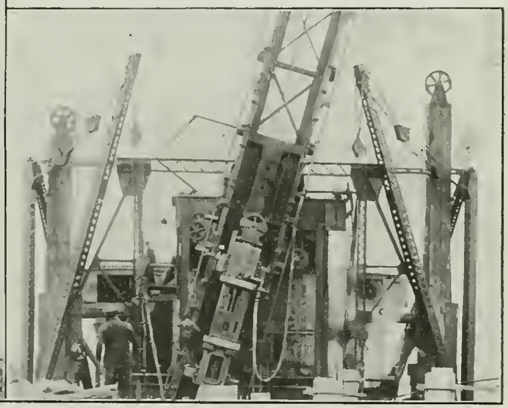


Fig. 8.—Details of Pile Hammer, on Head of Pile and Ready for Driving.

MORTAR-MAKING QUALITIES OF SAND.

THE importance of careful discrimination in the selection of ingredients of mortar is a consideration to which attention has been called frequently in these columns. The term "mortar," as defined by the American Railway Engineering Association, is a mixture of fine aggregate (sand or crushed stone screenings), cement or lime, and water, used to bind together the materials in concrete, stone, or brick masonry, or to form a covering for the same. Owing to varying geological conditions, sand, for instance, is one ingredient which may be expected to vary widely in character, and in practice it is found to fully comply with such expectations. In concrete construction the cement is nowadays subjected to careful inspection. The specification requires the sand to be "clean and sharp," although such wide latitude as has heretofore been allowed in its inspection is giving way to closer investigation and scrutiny. This is owing to failures that have been caused by deficiency in both durability and strength, that may be laid only to the inferior quality of sand used.

There is a growing demand for more information concerning the general characteristics of sands, as well as for reliable data on the mortar-making qualities of typical sands. The subject has been very fully discussed in a bulletin recently issued by the University of Illinois, containing a complete account of an investigation undertaken by Mr. C. C. Wiley, with the object of determining the relative value of a number of representative sands in common use in the cities of Illinois. It is of special interest to engineers and contractors, as the methods which it describes and the conclusions arrived at will be found distinctly useful for general guidance.

Description of Tests.—Each sand was tested for cleanness, gradation of size of grains (sieve analysis), specific gravity, voids, and weight. The approximate mineralogical composition and comparative sharpness were also determined. Tests for tensile strength were made on mortars made of each of the sands. In making all of these tests especial care was taken to eliminate the personal factor from the results. There were 576 briquettes prepared and tested, 18 for each specimen of sand. The mixture contained Portland cement, and the various sands mixed in the proportions of 1:3 by weight.

The sands were tested for cleanness as follows: 1,000 grams of the sand were thoroughly agitated in about one gallon of water. The mixture was then allowed to settle for about one minute, experience showing that this allowed sufficient time for the finest sand to settle. The dirty water was then siphoned off, care being taken that none of the sand was carried over with the water. This washing process was repeated until the water showed no discoloration. The sand was then transferred to a pan and as much water as possible drawn off by jarring the sand until the water flushed to the surface, and then removing the water with a pipette. The sand was then re-dried over steam coil and weighed. The loss in weight due to the washing was taken as the amount of suspended matter.

The following standard sieves were used: Nos. 5, 8, 10, 16, 20, 30, 40, 60, 74, 100, 150, and 200. The washed sand was then placed on the top sieve and the whole shaken for forty minutes on an agitator driven by power at 100 r.p.m. After shaking, the sand retained on each sieve was weighed and from these weights the percentage passing each sieve was calculated. In making these calculations the amount of suspended matter, as determined by the cleanness test, was included with the material passing the finest sieve.

The specific gravity of the sands was determined by means of a Schumann flask, consisting of a bulb or bottle into the neck of which a graduated stem fits with a ground joint. The bulb was filled with water and the height of the column of water in the stem read from the graduations. Fifty grams of sand were used and results checked by an additional 50 grams.

The large variation in the percentage of voids in sands as determined by different observers is doubtless due to errors of observation, particularly to a failure to compact all sands to the same extent. For the present series of tests some method of operation was desired which would compact all sands alike, and hence yield reliable results; and, further, a method was desired which would be easy to perform and which could make use of a limited quantity of sand. After a number of trials the following method was adopted:—

A graduated cylinder about 2 in. in diameter and of 500 c.c. capacity was used. About 20 c.c. of sand was placed in this cylinder and compacted by striking lightly with the cylinder on a pad composed of eight thicknesses of heavy cotton flannel. Twelve blows were given at the rate of about two per second with a fall of about one inch, care being taken that the blow was not hard enough to cause the sand to bounce, and also that the cylinder struck squarely so that the sand was not thrown from side to side. Successive increments of the sand were added in this way until the cylinder was filled. The difference between the weight of the empty cylinder and the cylinder full of sand gave the weight of 500 c.c. of dry, compacted sand. Then, knowing the specific gravity of the sand, the percentage of voids was computed from the equation

$$V = 100\frac{S - W}{S}$$

in which V is the voids expressed in per cents. of the total volume, W is the weight of the sand, and S is the product of the volume of the sand, its specific gravity, and the weight of a unit volume of water; i.e., S is the weight of an equal volume of sand containing no voids. In the present case S equals 500 multiplied by the specific gravity. The results obtained by the above method were quite uniform, the maximum variations from the mean averaging only from about 0.8 to 1.5 per cent.

The weight per cubic foot of each sand was computed from the weight of 500 c.c. The results averaged about 3 per cent. higher than the results obtained by other observers on similar sands, due evidently to a difference in the method of compacting the sands.

Mineralogical compositions and sharpness were determined by microscopical examinations.

Conclusions.—Following is a brief discussion of the series of tests and the conclusions arrived at:—

The mineralogical composition of a sand is the fundamental factor in its mortar-making qualities, since not only its durability, and hence the durability of the mortar, but the size and gradation of the grains, the nature of the grain surfaces, the strength of the grains themselves, and all the other factors which affect the strength of the mortar are more or less directly dependent on the nature of the component materials of the sand.

The specific gravity of a sand affords but little information relative to its mortar-making qualities, its principal value being as a factor in certain computations. Quartz has a specific gravity of about 2.65; and the nearer the specific gravity of a sand approaches this value the greater is the content of silicious material. A higher

value indicates considerable quantities of materials other than quartz, which are likely to be hard and durable; while a lower value usually indicates the presence of soft, unsatisfactory material, or of considerable quantities of clay and loam or other foreign matter.

Angularity or irregularity of the sand grains appears to exert no effect on the tensile strength of the mortar. In compression, the sharp sands may show a slight advantage due to the interlocking of the angular grains; but evidently such action is insignificant as compared with the resistance to displacement of the grains afforded by the bond between them, due to the adhesion of the cement to their surfaces, hence the strongest mortars are invariably those in which the cement most readily adheres to the sand grains. Crystalline rocks when freshly fractured generally show surfaces of great smoothness to which the cement does not adhere well; but when these grains have been worn down the surfaces become roughened and the cement adheres much more readily. This is particularly true of quartz, as is evidenced by the fact that rounded silicious sands usually form mortars of greater strength than similar sharp sands. With sands composed of rocks which naturally show a rough, granular fracture this advantage of round grains is lost, but in any case mortars made of round-grained sands will compact more readily than those of sharp sands; hence such mortars in place are likely to be more compact and dense, which conduces to greater strength. The usual requirements of specifications that sands for mortar and concrete shall be sharp is not only useless, but may even be detrimental, and should, therefore, be omitted. Further, since the condition of the grain surfaces does materially affect the strength of the mortar, the specifications should fully cover this point.

The percentage of voids in dry sand is a function of its compactness and the gradation of sizes in the sand grains, hence the effect of the voids on the strength of the mortar is included with that of the gradation of the sizes of the grains. The percentage of voids is valuable in determining the amount of cement necessary to give the densest mortar.

It has been demonstrated, both by experiment and practice, that coarse sands will yield denser mortars than fine sands, and that the maximum density is obtained when the various sizes of grains are present in the proper proportions. Just what the proper proportions are, or in other words, what the ideal form of the sieve analysis curve is, has not as yet been determined. Experiments with materials for concrete indicate that for a mixture of cement, sand, and stone the sieve analysis curve should approximate a parabola, and by analogy it would seem that the same should be true of a mixture of cement and sand as well. Assuming that the parabola is the ideal line for the mixture, and remembering that the cement is very fine, it follows that the ideal line for the sand considered alone must lie below the parabola, and that it would be different for each proportion of cement used. But since the cement is very fine and forms a relatively large proportion in most mortars, the consequent variation in the ideal gradation for the sand considered alone will not be great; and hence it may be said that for the common proportions of cement and sand (1:1 to 1:4) the flatter the sieve analysis curve of the sand the denser will be the mortar made from it.

It has also been demonstrated that, other things being equal, the denser a mortar the greater is its strength; and hence the size and gradation of the grains is indirectly a factor in the strength of the mortar. Unfortunately, the fact that "other things must be equal," has been frequently overlooked with disappointing and sometimes disastrous results. It is only when the various sands are identical in mineralogical composition, condition of the grain surfaces, cleanness, etc., that the size and gradation of the grains becomes the controlling factor in the strength of the mortar and even then it is only relative. Thus, if two sands are exactly alike in all respects except size and gradation of the grains, the better-graded sand will yield the mortar of both greater density and greater strength; but this strength may be decidedly less than that of a mortar from a third sand which may be less perfectly graded than either of the two given sands, but is superior in other characteristics. Consequently, we may have two sands which have identical sieve analyses and yield mortars of the same density, and yet these mortars may differ greatly in strength; or, two sands which differ greatly in their sieve analyses may form mortars of the same strength, although different in density.

Where strength is of the first importance in a mortar the only criterion is a direct test for strength; but after the absolute strength of the mortar from any one sand is determined, the sieve analysis may indicate whether the strength can be somewhat increased by improving the gradation of the sand. In general, this improvement must be accomplished by judicious screening rather than by the addition of other material, since usually the added material will not be of the same general character as the given sand. Where a dense or impervious mortar is required, the size and gradation of the grains is of more importance; and if strength is secondary, may control the choice of the sand. In this case the sieve analysis curves may be of considerable assistance in selecting the proper sand, or in indicating whether the desired results can be obtained either by combining several sands or by screening. In no case, however, should the direct test for strength be omitted, for a certain amount of strength is always required, and a good result for the sieve analysis is not sufficient evidence that the mortar will have sufficient strength.

The maximum size of grain permissible depends on the work for which the mortar is intended. For concrete the maximum size is now taken at 1/4 inch, but certain kinds of masonry, etc., require a much smaller maximum size. The maximum size of grain fixes the limits of sieve analysis, and consequently two sands may differ greatly in average fineness, and yet each one may be more perfectly graded, and hence more suitable for some particular work than the other.

Foreign material in a sand may affect the strength of the mortar by retarding or preventing the hardening of the cement, by preventing the adhesion of the cement to the sand grains, and if present in sufficient quantities by simple "dilution" of the cement. Organic matter is the most common source of trouble, but inert clay and loam may prove deleterious under certain conditions. Experiments indicate that finely divided inert clay or loam may be present in an average sand to the extent of 10 to 15 per cent. without appreciably affecting the strength of the mortar, provided the clay or loam does not adhere to the grains, while a very small quantity may seriously impair the strength of the mortar if it forms a coating around the sand grains.

The tensile strength of the natural sand mortars varied from 140 to 464 lbs. per sq. in. at the age of 90 days. By comparing the tensile strengths with the sieve analysis curves, it is seen that the coarser sands give the mortars of greater strength, and it will be noted that several of the sands show almost identical curves but that their tensile strengths are quite different, while still others, giving practically the same strength, differ greatly in their sieve analysis curves. An examination of the sands themselves shows that this variation is due to

some of the other characteristics of the sands. Only five of the natural sands gave a tensile strength greater than the Ottawa standard sand; and it will be noted that all of these are bank sands with rounded grains, comparatively well graded and containing considerable material other than quartz. The river sands showed less variation in strength than the bank sands, but this is to be expected since they differ less in composition, grading, and cleanness. It may, therefore, be expected that river sands will form mortars of only moderate strength, and that there is likely to be little variation between different sands; and that bank sands will furnish the mortars of greatest strength, but that the strength from different sands will vary through a wide range.

In an experimental investigation there is often a question as to how many individual results are necessary for the accurate determination of the result. It will be found that in any extended series of observed values of a single quantity one value is considerably less than the average, another considerably greater than the average, while the remaining values fill in the interval between these extremes more or less completely. If the values are platted as ordinates in the order of their magnitude with uniform horizontal spacing, the resulting curve will be found to have the form of an ogee or reversed curve, and the average value will lie at the point of reversal of the ogee. If the values are too few in number, the curve will be discontinuous, and the average value cannot be said to be accurately determined. As the number of values is increased the curve will become smoother and more complete; and it is only when the typical ogee form is distinctly and continuously outlined that the average value of the results can be considered as accurately determined.

The selection of the proper proportions for a mortar is essentially a problem in economics, whether the result to be attained is a mortar or concrete of maximum strength, or one of the greatest density and imperviousness, or simply one of sufficient strength for the purpose in hand. The object in any case is to obtain the desired result with the minimum cost. If this fact is kept in mind, it will become clear that it may really be true economy to spend what appears to be a considerable amount of time and money in investigating the available sands and determining the best combinations. Obviously, the saving to be effected varies with the magnitude of the work, and hence the bigger the job the more important it is that the materials be properly selected. If such investigations were generally made it would certainly result in reducing the careless and extravagant use of cement, the most costly material entering into mortar or concrete.

OIL IN JAPAN.

Alberta is not experiencing the entire universal supply of oil-boom excitements. It is reported that the Japan Petroleum Company recently completed a well at Kurokawa, Akita district, which proved to be a gusher, yielding 400,000 gallons a day. The news caused extraordinary excitement on the Tokyo Stock Exchange, and the company's shares rose from 86 to 200 yen in a very short time; and would have gone further, but the Exchange officials ordered dealings suspended.

According to the "Journal of Commerce" of Montreal, the statistics of the exports of iron and steel for the year 1913 show that Germany heads the list, with exports of 6,497,000 metric tons in 1913, against 6,042,000 tons in 1912. Great Britain comes second, with 5,050,919 gross tons, against 4,933,112 tons in 1912. The United States exported 2,760,133 gross tons, against 2,947,597 tons in 1912.

A NOTABLE SUBMARINE GAS SUPPLY.*

THE town of Christiansund, Norway, extends over the mainland and three islands, and, until recently, the question of lighting either by gas or electricity had not resulted in any practical scheme, owing to the unusual difficulties presented. It was optional for the municipality to either build their own works or place the work in the hands of a contractor. They preferred the latter, and the work of erecting gasworks and of further providing the main portion of the town, namely, Kirkelandet, with electricity, was given on the 17th of July, 1907, to Mr. Ferd. G. Juell and Engineer Karl F. B. Pihl. The concession was granted for twenty-five years, but the municipality reserved to themselves the

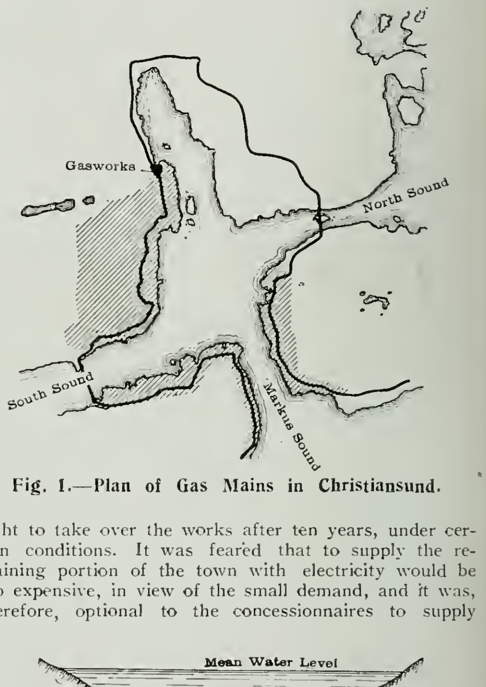


Fig. 1.—Plan of Gas Mains in Christiansund.

right to take over the works after ten years, under certain conditions. It was feared that to supply the remaining portion of the town with electricity would be too expensive, in view of the small demand, and it was, therefore, optional to the concessionnaires to supply

Fig. 2.—Section of the South Sound.

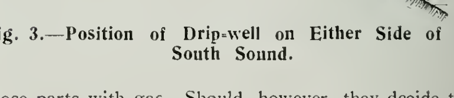


Fig. 3.—Position of Drip-well on Either Side of the South Sound.

those parts with gas. Should, however, they decide that this could not be done owing to the broad and deep Sound, then those parts were to be supplied with electricity.

* Translated from "Teknisk Ukoblad" by "The Gas World."

Preference was given to gas, owing to the advantages which it offered to the inhabitants, in so far as it could be used for lighting, cooking and heating, whereas electricity could practically only be used for lighting, and it was decided to go in for a submarine and long-

Fig. 4.—Sinking Gas Mains.

distance gas main, in spite of the difficulties offered by the Sound.

The main, which is 2½ miles long (half of which distance is without branch mains), is the only one of its kind in Norway, and, furthermore, it is surmised that there are no other submarine gas mains laid at so great a depth. As shown in Fig. 1, the gasworks is situated at Kirkelandet, from which one main goes round the Overvaagen, *via* Gromatlandet, through the North Sound to Nordlandet, and another main is laid from the gasworks through the South Sound to Inlandet. The main crossing the North Sound also supplies the small island situated in this Sound, and, as the depth of this Sound is only 24 feet, no difficulties were encountered during laying. The laying of the main in the South Sound, however, was a more formidable undertaking.

Fig. 2 shows a section of the South Sound. The submarine portion of the main in this sound is over 200 yards long, and its greatest depth below the level of the water is 86 feet. The depth of the Sound would, therefore, involve a maximum external pressure of 86 feet head of water, or 37 lbs. per square inch. In the case of a water main, a small leakage under these conditions would not be serious, or even with a sufficiently high-pressure gas main, but the supply of gas is designed for low pressure, only 15 to 25-tenths, and, therefore, it was necessary, above all, that the joints of the main should be absolutely tight. Furthermore, the difficulty of pumping any drip-well placed at such a depth enhanced the necessity not only of providing securely against leakage of water into the main from without, but also of obviating condensation within. The engineer, Mr. Pihl, appears to have worked on the lines of prevention.

In order to encourage condensation of gas in the main before or after its passage through the Sound, the pipes were laid above ground for a certain distance. Drip-wells were then placed on either side as shown in Fig. 3. Valves also are installed, and the main proceeds to dip under the water without any further provision, either for catching liquid or pumping it out. Four years of practical experience have proved that this bold scheme has been successful.

The submarine gas main consists of weldless Mannesmann steel tubes of 4 inches diameter, in lengths of 33 feet. They are protected against the action of sea water by means of galvanizing. They are also coated inside and out with rust-preventing mixture, and covered outside with strips of hessian soaked in a special tar preparation. The ends are threaded and the tubes connected by means of couplings with tightening cones, which type of joint has already proved satisfactory in a main at Vardo. The tubes were easily jointed up as per Fig. 5. They were bent on land to suit the shape of the banks, the remainder being allowed to adapt itself to the formation of the bottom of the Sound. The main was completely erected on a small island, inspected and tested to the requisite pressure. and was then brought by tugs into position, where it was sunk by divers, as shown in Fig. 4. During laying, a small tug was stationed at the entrance to the Sound to tow incoming steamers into port by another route. The sinking of the main was done quickly and safely, and not a single joint was damaged.

Fig. 5.—Screwing up the Joints of the Pipes.

Both submarine mains have now been in use for four years without interruption, and no accident has happened to them, except directly after laying, when an anchor, which was dropped without permission, got into contact with the main in the North Sound.

All four parts of the town are supplied with gas by these long-distance and submarine mains.

FLOOD PREVENTION.*

By Maj. J. C. Oakes, M.Am.Soc.C.E.,
Corps of Engineers, U.S.A.

FLOODS are caused by excessive rainfall, quick melting of a thick blanket of snow, or a combination of the two, quick run-off, and channels inadequate to take care of the resulting flow of water. The run-off may be hastened by frozen ground, or a ground saturated by previous rainfall so that all of the precipitation escapes rapidly. The natural channel capacities may be, and usually are, reduced by artificial obstructions which prevent free and easy run-off.

Flood prevention measures must reduce precipitation, retard run-off, or increase capacity of the channels. I think that it is generally agreed that it is beyond the possibility of human ingenuity to control precipitation. The only method that has been seriously advanced is by forestation, and even for that method I am not aware that its advocates claim that forests decrease precipitation. It is certain that for all practical purposes the control of precipitation by forests or other means is at present impossible.

Flood prevention must deal, therefore, with the other causes of floods.

Run-off may be retarded by the retention of precipitation on or in the ground, or by the use of reservoirs. Several means of holding the precipitation where it falls have been proposed, such as deep plowing, contour plowing, and forestation. The term deep plowing is self-descriptive and the method is advocated not only for the purpose of retarding run-off, but also as a means of improving the yield of agricultural land. If all cultivated land could be plowed deep and the material well broken up, a considerable amount of precipitation would be retained by the soil. However, as can be readily seen, as a means of flood prevention, it is hardly within the control of the government. Furthermore, with a serious storm it is very doubtful if more than a very small portion could be held in the soil, even if plowed deep. Again, a large part of the country is uncultivated and covered by forests, hillsides and towns. This method, therefore, is very limited in its application and apparently impossible of control.

Contour plowing is a term applied to the method of plowing which creates ridges following the contours of the land and forms, as it were, terraces in such a manner that water will be held where it falls. This method, or perhaps a modification of it by the use of small dikes, is used extensively in foreign countries, such as Japan and the Philippines, where there is an excess of rain in one season to be followed later by a season of drouth. Under such climatic conditions, holding the water on the lands becomes necessary, else no crop can be raised.

In the eastern and middle western states these measures are not necessary for agricultural purposes, and while, if used extensively, they would retard run-off to some extent, they are impossible of control.

Both of these methods, therefore, seem to have advantages within certain limits, and would seem desirable, but they are not feasible means.

This brings us to forestation. This subject was treated at some length in the report of the National Waterways Commission, and the following is quoted from their report:

It is generally admitted that forests exercise such reservoir characteristics and under favorable conditions to a sufficient extent to improve the regularity of stream flow. There is, however, a decided limit to the quantity of water which a forest cover can absorb. The capacity for absorption varies greatly under different conditions, depending upon the depth and character of the forest litter, as well as of the soil underneath, whether pervious or impervious, also upon the condition of the ground, whether frozen or not, upon the steepness of the slope, and numerous other factors. Where the forest litter is destroyed by forest fires, or is removed to prevent them, the absorptive capacity is thereby reduced.

Various experiments have been made to ascertain the amount of water which different kinds of forest litter could absorb and hold. The results show that in general an amount equal to a precipitation of 0.16 of an inch can ordinarily be retained, while under favorable conditions the absorption of an amount equal to 0.24 of an inch or even more is possible. The soil beneath the humus may also be capable of some absorption. As soon as the saturation point is reached, additional rainfall must necessarily run off on the surface just as if the ground were deforested. This explains why forests are powerless to prevent floods, although, to the extent that they do absorb the precipitation, they may mitigate them.

Effects of Forests Upon Floods.—Floods are caused primarily by a heavy and prolonged precipitation, amounting oftentimes to several inches within twenty-four hours. During the heavy rains which caused the disastrous floods in the Passaic Valley in October, 1903, 14 inches fell, according to records taken at New York and Newark. The worst floods usually occur in the spring when these heavy rains fall upon a considerable accumulation of snow, which melts rapidly and augments the amount of water already precipitated. At this time the ground is more apt to be frozen or saturated and its capacity for absorption to that extent impaired.

Forests retard the melting of snow in the spring and by allowing the water from this source to be absorbed, exercise a beneficial influence upon stream flow, but should heavy spring rains fall upon the snow thus preserved and cause it to melt within a few hours the effect of the forest is in such a case to aggravate rather than ameliorate flood conditions. It thus appears that under one set of conditions forests may exercise a beneficial influence upon stream flow and floods, while under another their influence will be harmful.

Assuming that the above is a fair statement of the effects of forest on stream flow, it will be noted that an amount of precipitation equal to 0.16 of an inch can ordinarily be retained, while under favorable conditions the absorption of an amount equal to 0.24 is possible. Applying the factor of 0.16 of an inch to the State of Ohio, and to the storms which created the flood of March and April, 1913, if the whole State of Ohio could be reforested and could retain 0.16 of an inch of rainfall, only 2⅔ per cent. of the total rainfall would have been retained by the storage effect of this forest. The present forest area of Ohio is about 9,000 square miles, or a little less than one-quarter of the State of Ohio. If we could imagine an additional 10,000 square miles of present cultivated land back into forest, this additional forest under the most favorable hypothesis would retain only two-thirds of 1 per cent. of the rainfall of such a storm as that of March 23-27, 1913.

*Address delivered before the Indiana Sanitary and Water Supply Association, Indianapolis, Ind., February 26, 1914.

This subject was very thoroughly discussed in the Transactions of the American Society of Civil Engineers in connection with an article by Brigadier-General H. M. Chittenden, Corps of Engineers, U.S. Army, on the subject of "Forests and Reservoirs in Their Relation to Streamflow, With Particular Reference to Navigable Rivers." As illustrating the bad influence that forests may have upon run-off, he states:

In the first place, forests break the wind, prevent the formation of drifts and distribute the snow in an even blanket over the ground. * * *

The water from the first melting of the snow blanket does not sink into the ground, but into itself. The forest shade thus holds the snow, which gradually becomes saturated from its own melting until the heat and warm rains of late spring and early summer arrive. * * *

The result is that when the final melting begins, the whole body of snow disappears very rapidly, rushing from every direction into the streams, swelling them to their limit and often causing disastrous freshets. * * *

The delay in melting caused by the forest shade has simply operated to concentrate it into a shorter period and increase the intensity of the resulting freshet.

I believe that all of us will agree that the above statements are correct under certain conditions, and that by retarding the melting of the snow, forests have, on occasions, contributed to disastrous floods. Furthermore, even if it could be proven that forests exert on the whole a very beneficial effect, it is impracticable to convert fine agricultural land into forests. This country is certain to be more thickly settled than at present, greater crops will be needed for the support of the people and all tillable land will be ultimately used for the cultivation of crops until timber becomes so scarce that its value will pay the farmer to set aside a portion of his farm for its cultivation. Another objection to this method is that the formation of a humus sufficient to have its maximum effect in absorbing rainfall requires a long period, probably at least a century.

For these reasons it seems to me inexpedient to advocate reforestation as a means of prevention of floods.

The last mentioned and most feasible method of retarding run-off, is by the use of reservoirs. We have heard much on this subject within the last few years, and it has become a popular remedy for the prevention of floods.

If a certain amount of water flows downstream creating damage during its flow, it is apparent to anyone that if that water can be held in a reservoir and allowed to escape slowly, no damage would occur. Therefore, without understanding the immensity of the problem the ordinary man thinks he sees a remedy for floods and proceeds to become an advocate of what has come to be known as the reservoir method of flood prevention.

I desire to dwell on this subject at some length, for the purpose of showing that the problem is not as simple as stated above. There are without doubt many localities that may be protected by a reservoir or reservoirs. For instance, in the study of flood protection for the city of Columbus, O., the engineers were able to show that there were available sites immediately upstream from that city, which could be converted into holding reservoirs sufficient to take care of a flood similar to that of March and April, 1913. If such reservoirs had been in operation and had been controlled properly, releasing only sufficient water to fill the channel and not overflow the banks, no serious damage would have occurred in Columbus. It is also reported that the consulting engineers for the city of Dayton have shown that not only that town, but several others in the immediate vicinity, may be protected in like manner. The Pittsburgh Flood Commission has studied the subject in connection with flood protection for their city, and they have evolved a plan which appears to be ample to provide against future disastrous floods at Pittsburgh, if, however, the control of the reservoirs is possible to obtain results in accordance with the plans.

When one comes, however, to consider the prevention of floods in a river system like that of the Mississippi, the problem becomes exceedingly difficult. In the first place, reservoir sites are not generally found close to the points where the damage will occur, and this is particularly true of the Mississippi.

Col. C. McD. Townsend, Corps of Engineers, U.S. Army, president of the Mississippi River Commission, in an address before the Drainage Congress in the spring of 1913, stated:

To have retained the Mississippi flood of 1912 within its banks would have required a reservoir in the vicinity of Cairo, Ill., having an area of 7,000 square miles, slightly less than that of the State of New Jersey, and a depth of about 15 feet, assuming that the reservoir was empty when the river attained a bank-full stage. Cairo is the logical location for a reservoir to regulate the discharge of the Lower Mississippi. It will not only control the floods from the Ohio, but also the discharge from the Missouri and Upper Mississippi. But if the reservoirs be transferred from the mouths of the tributaries to the headwaters, their capacities must be largely increased.

It is not to be supposed that the people of Illinois and Missouri would be willing to have a portion of their territory as large as the State of New Jersey turned into a reservoir.

In this connection it should also be remembered that at the headwaters of the Mississippi there is the largest artificial system of reservoirs in the world, with a capacity of 93,000,000,000 cubic feet. These reservoirs have been successful in slightly increasing the low-water discharge of the Mississippi River above St. Paul, and also in reducing floods in that portion of the river; but a hundred miles farther downstream it is impossible to detect their influence during either high or low water.

The Ohio River has a very large flood discharge. At Louisville, for instance, the maximum discharge is 790,000 c. f. s. At the mouth of the Ohio the estimated maximum discharge amounts to 1,500,000 c. f. s. Let us see what effect the system of reservoirs proposed for the protection of Pittsburgh would have had at Louisville during the flood of March-April, 1913. The Pittsburgh Flood Commission proposed the construction and operation of seventeen reservoirs whose total capacity is approximately 59,500,000,000 cubic feet. The amount of water flowing past Louisville during the day of maximum height was approximately 67,392,000,000 cubic feet. The proposed reservoir system, therefore, would have been more than filled by one day's flow at Louisville. If we assume that the dangerous flood height at Louisville is 54 feet, then, to have kept the river below that height during that flood, a storage capacity of 7,300 square mile feet, equal to 200,000,000,000 cubic feet, would have been required, or over three times the capacity of the proposed Pittsburgh system.

If there had been a reservoir just above Louisville, with a capacity of 7,300 square mile feet, and if such reservoir had been empty when the flood stage of the Ohio River occurred, the Ohio River at Louisville could have been kept below the flood stage. But anyone can

see that it would not be feasible to construct a reservoir of such capacity between Pittsburgh and Louisville because of the great value of the land, towns, improvements, etc., that would be submerged.

Another illustration may be taken from the Wabash River. To have kept the Wabash within its banks at Mt. Carmel between the date of March 25th and April 21st, would have required a storage capacity of 260,000,000,000 cubic feet, amounting to 9,300 square mile feet. This would have required a reservoir or reservoirs having an area of 930 square miles with water at average depth of 10 feet. It is apparent to anyone who knows the territory along the Wabash River that it would be impossible to find any such reservoir site in the vicinity of Mt. Carmel, and even if found, the cost of such site would be prohibitive.

It is evident, therefore, that on the large rivers like the Mississippi and the Ohio, there will be few reservoir sites close to the main streams that can be used to control floods and that sites must be found on the tributaries and generally at their headwaters. This complicates the problem and makes large numbers of reservoirs of immense capacity.

If reservoirs are to be located on the headwaters of the tributaries, then sufficient capacity must be provided on each of the tributaries to allow for its maximum flood. This capacity will be many times the capacity estimated from the discharge of the main stream, because floods are generally caused by the flow from a number of tributaries, but seldom from the flow of all the tributaries at their maximum stage. Thus each individual tributary must be treated and reservoirs must be so operated that they will be empty when needed and when full they must be emptied slowly so as to prevent the piling up of water in the main stream.

A marked defect of this system is the possibility that one storm may follow another so closely that at the time of the second the reservoirs will be full and not available for storage purposes.

Besides the points mentioned above, there enters the question of costs. Reservoir sites are, in general, extremely costly. The Pittsburgh Food Commission estimated the cost of its proposed system at $21,000,000, but a Board of Engineers, U.S. Army, in reviewing the report found that land and property damage were underestimated by $13,000,000, so, if their other estimates were correct, the cost would be $34,000,000. If a complete system were practicable for the Ohio River, some idea of its probable magnitude may be gained from the fact that the area of the basin of the Ohio Valley is 204,320 square miles, while the drainage area of the rivers above Pittsburgh just referred to is but 18,920 square miles, or 9 per cent. of the whole. Assuming that the cost per square mile would be the same as that for the Pittsburgh system, the total cost of providing reservoirs for the Ohio River would be $378,000,000. It is probable, however, that these costs would be greater, for the territory in question above Pittsburgh is not nearly as valuable as in such States as Ohio, Indiana, and Illinois.

The advocates of reservoirs for flood prevention recognize the enormous cost of this method of protection for a large river like the Ohio, and to offset this very pertinent objection they claim that the water stored in reservoirs may be used to produce power which may be sold to the public, thereby reducing the cost of flood prevention, and may also be used to increase the low-water flow of streams thereby improving navigation.

It is true that reservoirs may be used for flood prevention and the water held therein used for power, or for increasing the low-water flow of a stream, but the full capacity of a reservoir may *not* be used for all three of these purposes at the same time. Reservoirs to be used for flood prevention must retain the water during the possibility of floods, but the instant that possibility passes the water must be allowed to escape as rapidly as possible without doing damage, in order that they may be empty at the time of the next possible flood. The use of reservoirs for increasing the flow of streams at low-water stages is just the reverse of this. They must be kept full as long as possible and the water only allowed to escape when it is absolutely necessary to increase the low-water flow. The use of reservoirs for power, on the other hand, requires a constant flow with a constant head to obtain the best results, and the more nearly these conditions are met the more efficient is the plant and the greater income obtainable from a given expenditure.

A little thought on this subject will convince a reasonable man that the three uses of reservoirs proposed by their advocates are incompatible one with the other, and in my opinion if an endeavor were made to use the same reservoirs for these three purposes it would not be long before the power interests would obtain control, and it would be practically impossible for a government agent to empty a reservoir in anticipation of a flood when the power interests desired the reservoir to be kept full in order to provide uniform power for their plant.

In any case, it will be seen from the above that to prevent floods by the use of reservoirs will require a certain definite capacity; that if these reservoirs are to be used for any other purpose their capacity must be vastly increased, thereby increasing the costs of the system. Before the feasibility of protection by reservoirs in any particular case can be affirmed, available information must be supplemented by extensive, reliable data as to run-off, flood heights and discharges, available sites and costs.

The capacity of streams may be increased by the use of levees, dredging, or auxiliary channels.

With reference to the levee as a means of flood protection, it has been used for many hundreds of years. It is a means available for the immediate protection of sites or areas of varying size. Large areas of the Mississippi basin are protected by levees, as well as many towns on that and other rivers. New Orleans and Cairo are so protected. With this method the solution is simple, and the only important questions are to determine the size of the levees and the cost. An area may be made secure against any flood of similar height to those we have had in the past, or that may be expected in the future. The method is simple and direct and is the only method extensively used for protection in cases of large river systems. The levee system on the Mississippi has been in process of construction many years, and while it is true that breaks occur which cause vast damage, it is due to the fact that such levees have not been constructed to the height necessary for protection against the greatest floods. Where a community felt itself too poor to provide against the highest floods they have built their levees as high as their funds would allow, with the expectation and knowledge that when a higher flood came the levees would be topped.

Dredging may be used for increasing the capacity of channels where the increase required is very moderate, but a radical increase in the capacity of a large stream may not be accomplished by this method without the expenditure of enormous sums of money. A point often forgotten is that dredged material must be placed outside of the river channel if the dredging is to do any permanent good. This requires the purchase of lands upon

which such material may be deposited, and increases the cost of actual dredging very materially.

No instance is known where a radical increase by dredging of the flood-carrying capacity of a river channel has been attempted on any large stream. The low-water channels in streams like the Mississippi oftentimes are dredged to facilitate navigation, but it is believed that the limited application of this method should be apparent.

Auxiliary channels have been suggested, both paralleling long stretches of streams and also to form cut-offs. The cost of providing additional channels for a stream like the Ohio or the Mississippi, of sufficient capacity to carry off the flood waters, is absolutely prohibitive. For the protection of a particular locality short auxiliary channels or cut-offs may be used, but these have the disadvantage that while they may benefit the locality in question by facilitating the run-off past that particular locality they pile the water up more rapidly below, thereby creating more damage at other points, as they necessarily cause steeper slopes, higher velocities, and greater erosion.

The method of prevention of floods have been discussed at some length, and it must be realized that the subject is one of great extent and the problem in the case of large streams very difficult of solution.

We now come to the question of the prevention of damage by floods.

Many towns have grown up on the flood planes of the streams, occupying areas that have been overflowed from the beginning; people have entered the bottom lands and erected their structures with the knowledge that those lands were formed by silt deposited by flood waters; railroads have constructed earthen embankments across these bottoms, leaving only very narrow openings with wholly inadequate capacity for passing floods; city and county officials have built bridges with abutments projecting into the stream, with many piers of insufficient height, thus reducing the discharge area materially; individuals have dumped materials over the banks to increase the area of their property for business purposes. These structures and encroachments have reduced the capacity of the streams, have formed partial dams which raise the water above previous levels and then by the breaking of an embankment or the washing out of a bridge the water held back has rushed downstream under increased head and velocity, destroying everything in its path. Aside from the damage done by the inundation of property, which, while serious, is not destructive, almost all of the damage at the points visited is caused by increased velocities of current due to the backing up of the water, by embankments, bridges, and other structures, the subsequent breaking of these partial dams and the rush of the released waters under increased heads and velocities.

The measures to be taken to prevent such damage are: wherever possible, to remove structures from the flood planes and river bottoms, or to elevate such structures above possible high water; to protect by levees valuable property which it is impossible to remove; to prevent the construction of heavy earthen embankments across flood planes by railroads or counties; to increase the capacity of channels by removing encroachments thereon in the shape of bridges, buildings, etc., and to remove all artificial and natural filling or deposits.

Fire has recently completely destroyed the Oceanic dock at Portland, Ore., and has entailed a damage loss of $150,000. The dock was owned by Balfour, Guthrie and Company. The fire was the third destructive waterfront blaze this spring, all along one section of the Portland waterfront.

SUBURBAN, INTERURBAN AND RURAL ROADS.

SOME valuable suggestions as to the classification of public highways and the proper division of expenditures for their construction and maintenance appears in the 1914 report of the Public Roads and Highways Commission of Ontario. In discussing the subject of supporting areas for cities, the report emphasizes the value to the latter of general rural development brought about by better roads.

Urban centres with good roads are especially benefited by the main roads in their immediate vicinity. It may in a general way be assumed that each city has a special interest in an area immediately surrounding it, sufficient to provide a food supply for the city, and the population within such area.

Attention is called in this report to one or two preliminary points. It is well known that cities are not, even in the matter of home-grown products, supported altogether by their immediate neighborhoods.

It would seem, however, that the most potent influence in preventing such a condition has been the heretofore inadequate means of local transportation in marketing. Improvement in these facilities would induce the abandoning, by nearby farmers, of low-priced crops, which have heretofore carried the bonus of cheap marketing, for high-priced crops upon which marketing charges will decrease as the farmer is brought closer to his market.

Then again, some districts are specially adapted to the production of certain products, such as fruits, and they should, therefore, be properly expected to specialize in the production of these commodities. This factor has its effect in altering any general calculations that may be made for cities and their supporting area as a whole.

Still another point arises with the calculation of a large supporting area. A number of towns of various sizes are found within the area. In this instance, therefore, a special calculation has to be made and the results tabulated. In the case of the smaller cities, however, this difficulty is not incurred.

In all, calculations have been made for the twenty-one largest centres in Ontario. The results appear in the table given on the next page.

The results given are based upon calculations in which both the general items of food entering into the dietary of the average family, and the yield of these items in the various districts respectively, for which estimates are presented, have been taken into account. The "average family" was taken consisting of five members. There was then worked out the acreage required to supply the various food items appearing. The total area required for the support of fifty people for one year was thus found to be 109.14 acres. It is to be noted that this acreage provides only the amounts of each kind of food grown locally and consumed by the unit of fifty people in one year and no account is taken whatever of other foods, such as imported fruits, etc., which are consumed in addition. The 109.14 acres thus represents the area required to provide home-grown products only. It is to be further noted that this acreage represents only the net area required, and this whole area of land would need to be cultivated to provide the required amount of food. In the case of each area for which a calculation was made, therefore, account was taken of the proportion between cultivated or producing land and total acreage.

It will be noted that when the circles designating the supporting areas are placed upon a map, certain of these, if carried through, would intersect; the conclusion being that the supporting areas of various cities are found to

overlap each other. It therefore becomes necessary to make allowances in these cases. The smaller city is favored in that the amount of overlapping, when taken from the larger area, makes but a slight difference in its total, whereas the same amount taken from the smaller area would make a very appreciable difference. Furthermore, the areas where overlapping takes place lie, with one exception, closer to the smaller than to the larger urban centre.

Name of City	Population	Total supporting area. (Sq. miles.)	Radius of circle or part of circle of total supporting area. (Miles.)	Radius of area of immediate support. (Miles.)
Toronto, city only (Census 1911)	376,538	1676.8	....	32.7
City, 1913 (Assessment figures)	445,575	2591.9	....	35.3
With country (census)	458,432	2225.4	37.6	....
With country, 1913 (Assessment)	533,411	2591.9	40.6	....
With country and towns, 1913 (Assessment)	573,728	2905.9	43.0	....
Ottawa	87,062	621.25	19.8	16.8
Hamilton	81,969	730.84	15.9	11.8
London	46,300	326.18	10.1	8.3
Brantford	21,132	161.82	7.2	5.5
Kingston	18,874	126.77	8.9	7.8
Peterborough	18,360	148.49	6.9	5.6
Windsor	17,829	119.98	9.6	7.7
Berlin	15,196	104.28	5.8	4.8
Guelph	15,175	97.95	5.6	4.8
St. Thomas	14,054	79.98	5.1	4.4
Stratford	12,946	75.71	4.9	4.3
Owen Sound	12,558	99.67	5.9	5.1
St. Catharines	12,484	101.76	8.0	6.4
Chatham	10,770	60.35	4.4	3.8
Galt	10,299	68.04	4.6	4.0
Sarnia	9,947	80.21	7.8	6.7
Belleville	9,876	63.88	6.3	5.4
Brockville	9,374	73.21	6.8	5.8
Woodstock	9,320	53.69	4.2	3.7
Niagara Falls	9,248	69.56	6.6	5.1

Road Classification.—It has been pointed out that while municipal responsibility should be encouraged, there is a point at which, in order to obtain results, the influence of a central authority must bear directly upon road administration. A consideration of the classification of roads will assist in determining the point at which the forces of a central administration should be applied.

Roads should be built to meet the needs of traffic. For example, there are roads which, lightly traveled, by an initial expenditure of $1,000 a mile, will remain in good condition for ten years; on the other hand, there are other roads which, because of heavy traffic, demand an outlay of $1,000 per mile annually for maintenance alone. For this reason, roads admit of classification according to traffic for purposes of construction and maintenance, revenue and administration. They must be constructed and maintained adequately; revenue must, in equity, be derived from those who are benefited and organization must be commensurate with the work.

Cities and Suburban Roads.—The opinion is frequently advanced in the cities that the provision and support of good reads should fall upon the farmer, inasmuch as he must use them to market his products. The farmer, however, is fully justified in maintaining that the cities are equally interested in the roads over which their food supplies reach them. In point of fact, the city and country are necessary to each other, with the advantage somewhat on the farmer's side; for, while he could manage without the city, the city could not exist without him.

About each city there exists, as stated, a belt of rural territory which is knit to it in the closest fashion. Much of the city's food is grown in this belt; more would be if the means of communication were better. Sundry industries, due to the presence of the city, are prosecuted in this area. The residents for some miles out are valuable customers of the city's shops. In every way the city stands to gain by the equipping of this belt with a system of roads able to carry a heavy traffic with speed and economy. The speed of the motor bus and motor truck would extend the city's influence—that is, the area from which it could draw food and direct trade. Opportunities would be afforded for a specially beneficial development, the rapid moving of workers out into the countryside after their daily task is over. It is understood that in Belgium one-third of the industrial workers live outside of the towns, cultivating small holdings of land, under conditions of health which surpass those of residents in the crowded streets. From the standpoint of the city's food supply alone, the improvement of the roads is of great importance to the town dwellers.

Economically speaking, distances are measured by time, and if men trespass too much on the early morning hours in order to reach distant markets, nature makes her claim on them later on. If the constant, regular supply to city markets is limited to points, say, two hours therefrom, it would mean leaving the farm at 6 a.m. in order to be on the market stand at 8 a.m. It is easy to realize, therefore, that by cheap motors and good roads the supply area can be greatly enlarged, as compared with the present districts surrounding most cities, in which supplies are sent into town by horse-drawn vehicles on indifferent roads. Further, the widening of the belt means enhancing the profits per acre, to the advantage of the farmer.

Again, the countryside has suffered for several decades from certain inevitable developments. Forty years ago a considerable amount of industrial work was carried on in nearly every small town, in nearly every village, and, indeed, in many rural communities too small to aspire to the name and style of village. This caused a wholesome diversity of industry, increased the interest of country life, and was in most respects a beneficial social influence. The march of progress has swept that state of things away. The tendency of the age is toward centralization. Those small industries, which meant much to the small towns, have been absorbed into those operating in larger centres. The countryside must specialize in farming. Why, then, should cities—to a certain extent built up by rural districts, which have lost taxable property to those cities—not be prepared to contribute to the road system by which both benefit?

Interurban Roads.—In dealing with interurban roads it is necessary to glance at one aspect of the problem created by the motor. The greatest asset of some European countries is their scenery; it attracts tourists, and the money they spend is of great importance to the community. Bearing in mind that the tendency to reach summer resorts by motor is increasing, it is not difficult to realize that, with a system of main arteries penetrating country regions in the United States and Canada, a more important tourist traffic would be developed. This traffic is of little benefit to the people of the intervening districts traversed; it throngs the roads, and there is a tendency

to over-rapid driving, with its accompanying nuisances, of which the dust evil is but one. However, the traffic is of great value to the summer resort region, which would be the goal of most of these hurrying wayfarers, and the interests of such regions must be considered as well as those of the more strictly farming districts.

Along the interurban roads many persons will pass who do not live in the municipalities in which they are situated. This is perfectly natural; from time immemorial the King's highway has been for the use of the traveler, regardless of his residence. It is necessary, of course, to see that the burdens of constructing and maintaining such a road are equitably adjusted, so as not to impose an undue proportion of them on the people of the locality. Indeed, if measures of this sort are not taken, the situation will work itself out, and disadvantageously to all concerned; for the motorists will search out and appropriate to their use the best stretches, and there will be motor routes which at once will give dissatisfaction to the motorists and inflict a sense of injury upon the farmers and ratepayers along them.

At the same time, a road which constitutes an artery of this sort is not exclusively an affair for the traveller from a distance. It is a series of links—market roads necessary for the needs of local people, and it will be the strictly local road for those who dwell along it. In short, it discharges functions at once local, provincial, and in some cases even national, and in consequence it demands assistance from more than local administrations.

Rural Roads.—It can hardly be doubted that there is impending a revolution in farm operations. Two centuries ago or less the European farmer used the pack-horse to take his products to market. A revolution in methods occurred, and he came to employ wagons, which were hauled along roads much better than the tracks his ancestors had known. The self-propelled vehicle has come to stay, and the successful solution of the problem of good roads in some part depends upon a recognition of that fact. Indeed, the motor, to no small extent, creates the problem, for it has proved so destructive to main highways which resisted the wear and tear of horse-drawn vehicles that means must be devised to guard against a deterioration which now proceeds with a rapidity formerly unknown. Opportunities as well as difficulties are created by this new method of transportation. It prevents some, at least, of the features essential to profitable use by farmers; it conveys loads of a size so moderate that a single farm can furnish one or more than one, yet so large as to out-class the old horse-drawn wagon; it requires, not specialized tracks, like railway, but a common highway, albeit improved to a standard within the reach of the community; it is free from the difficulties of traffic adjustment which have made the conduct of railways a business by itself, and a peculiarly difficult business. In short, it is an individualistic method of transportation, and this commends itself to farming, the most independent and individualistic occupation in the world. Already there are cheap motor cars and trucks to be obtained; the farmer of to-day can procure one of these with as little straining of his resources as his grandfather could a top buggy; and it is but reasonable to expect a further lowering of the price. In this beneficent revolution, good roads must play a necessary and important part.

Increasing attention must be given, not only to the important market roads, but also to the township roads, those gravel or earth highways which pass the doors of the great mass of farmers and afford them access to the country or market roads, which lead to the centres where they sell their products and make their purchases. In Ontario these township roads are estimated at 85 per cent. of the whole of the highways.

It is proposed that township councils should provide for and control the roads of local travel, with the proviso that to encourage better methods and organization the province will grant a subsidy of 20 per cent. of their annual expenditures for a limited period of years. Such aid should not, however, be given to townships until the county has assumed a system of market roads; otherwise, as alternative plans, they might seriously interfere with the installation of a proper system of such county roads. It is felt that provision for a system of good market roads in each county is of first importance and that aid to townships should not be in any way allowed to take the place of such roads. As to the division of cost for rural market roads, it is suggested that 60 per cent. of both construction and maintenance expenses be paid by the county, and 40 per cent. by the province.

Future Development and Maintenance.—In the present circumstances, the general condition of rural roads being so indifferent, interurban and market routes have a tendency to shift, as one stretch of road is improved or another allowed to deteriorate, so that the volume of traffic borne by a particular route is not an absolute proof that under a proper organization of the road system it would not be a main traveled road. A road census would show what amount of travel is furnished to-day by a given district, and the channels which it now takes; but considerations such as the density of population, the productivity of the land, railway construction, possible or probable developments, the distribution of road-making material, and so forth, would have to be taken into account.

One such consideration is the possibility of future urban growth which will lead to the places concerned sending out and attracting to themselves a greatly increased volume of traffic; should this occur, the place so developing would need additional market and interurban routes, striking out from it at varying angles, and in some cases cutting diagonally across the present rectangular road-patterns. It is suggested that tentative plans for such diagonal roads be drawn up with regard to certain prominent centres, and some arrangement—such as the prohibition of the erection of buildings in their track—be made to ensure the possibility of their being constructed at the lowest possible cost, if need should arise in the future.

It is the opinion of the Ontario Highways Commissioners that if due care is taken in studying the situation, the county roads, those taking care of the heavy non-local traffic, need not greatly exceed fifteen per cent. of the whole. Thus they view the problem in Ontario as that of bringing 42,500 miles of township roads to a reasonably fair standard, and of fitting 7,500 miles of county roads to bear the severe demands made upon them.

The first principle in connection with road expenditure is that money secured by bond issues should only be put into permanent roads. The future should not be called upon to pay for the present, unless the present creates something that will be useful to the future. The maintenance of permanent roads is made necessary through the wear and tear of the present generation, hence that burden should be met by the users. As bond issues must eventually be redeemed, and as the roads will wear out and call for renewal from time to time, the bonds should not run for a longer period than the natural life of the road with proper maintenance. It is believed, therefore, that the bond should preferably be redeemed within twenty years, and should not exceed thirty years.

Maintenance would become increasingly heavy as stretch after stretch of standard roadway came into existence; from the moment a permanent road is constructed, a properly organized system of repair and upkeep must be applied to it if the first expense is not to be wasted and the project to issue in disappointment.

An intelligent system of records and cost-keeping is a basic requirement in an undertaking such as road construction and maintenance, for the guidance of those in charge of the work, as well as for the information of the public who supply the funds. Economy of expenditure, and public confidence and support, will be greatly aided by adequate records of work done with a corresponding and lucid statement of expenditure.

A NEW EXPLOSIVE.

TITANITE, a new explosive, which has been invented recently in Vienna, and for which many advantages are claimed, is an ammonium-nitrate and turmeric powder compound. The turmeric root is nitrated by boiling in water to extract coloring substances, drying, grinding, treating with a mixture of sulphuric and nitric acids, washing and drying the product of the reaction. Carbonized turmeric powder may be similarly nitrated. Ammonium-nitrate explosives usually contain carbonaceous material and carbonized turmeric powder and carbonized sandalwood are recommended as excellent for this purpose, the sandalwood hastening the speed of combustion. As a formula for an explosive compounded along these lines, the following is suggested: Ammonium nitrate, 88 per cent.; carbonized turmeric powder, 1.05 per cent.; carbonized sandalwood, 0.95 per cent.; nitrated turmeric powder, 10 per cent.

It has been found, however, that the carbonized material is unnecessary when the nitrated turmeric powder is used, and a simpler formula offered is: 80 to 90 parts of ammonium nitrate and 20 to 10 parts of the nitrated turmeric powder, carefully dried, intimately mixed and finely ground.

The addition of trinitrotoluene and gelatin, the latter consisting of collodion cotton and dinitrotoluene, results in an explosive of greater strength. A formula for such a compound would be: Ammonium nitrate, 82 parts; nitrated turmeric powder, 4 parts; trinitrotoluene, 10 parts; gelatin, 4 parts (the latter to consist of 0.17 part of collodion cotton and 3.83 parts of dinitrotoluene.)

It is claimed that these explosives are stable when stored, the hygroscopic quality of the ammonium nitrate being overcome; that they are entirely safe, being insensitive to blows, shocks and fire, and exploding only from an initial explosion as by a powerful detonator; that they are powerful in their effect, and that they yield only a small amount of noxious gas. As a matter of fact, according to the Engineering and Mining Journal, these claims have been pretty well borne out by trial at one of the largest mines in America. The difficulty in the way of the general introduction of the explosive, which is called titanite, seems to be that ammonium nitrate cannot now be obtained quite cheap enough to enable the titanite to compete in price with the other high explosives in common use.

The great dry dock in Japan at the Maidzura naval station on the western coast, has been completed after 8 years' work. It will accommodate warships up to 35,000 tons displacement.

MODERN METHODS OF STADIA SURVEYING.

By J. A. Macdonald, Ottawa, Ont.

ONE of the reasons why the stadia is growing rapidly into more general use is that fewer men are required for a stadia party than for an ordinary transit party. This particular advantage of the stadia over the transit and chain for the traversing of lakes has caused the Topographical Surveys Branch of the Department of the Interior at Ottawa to adopt the stadia almost exclusively for lake traverses. In the Lands Survey Branch the stadia is used almost entirely, also for all lake traverses necessary to be made in the subdivision of townships. This article embodies the best methods to adopt for surveying by means of the stadia rather than the chain and transit or compass. By reference to Fig. 1 it will be seen that the rays of light proceed from a point so distant that in the stadia the rays may be considered parallel, and these are refracted and converged to a point in the axis of the lens called the focus, or the principal focus, at a certain distance, depending upon the radii of curvature of the surfaces of the lens. The image is formed at the distance, F, in front of the object glass owing to the image of the cross-hairs being projected beyond the objective to the extent of the focal length of the latter. The rays converge at that point, and the measurement must be taken from it. Therefore, in order to obtain accurate results a constant must be added to the reading from that point, which constant is equal to the focal length of the objective, plus the distance from the objective to the centre of the instrument. The focal length is shown by the dotted line, f, while the distance from the objective to the centre of the instrument is shown by the dotted line c. The rod-reading gives the distance only from the point, F, to the rod, so that to get the total distance from the point over which the instrument is set the values of c and f must be added. The distance, then, is the rod-reading (assuming it reads 1 in a 100) of the rod plus $(f + c)$ in all cases. Each instrument has an individuality of its own, and must be adjusted by actual trial at a mean distance. The difference of focal length for an 11-inch transit telescope of 30 magnifying power at a change in distance from 100 to 300 feet would be but 0.0027-ft., so that it is possible to read all lengths of sights with an almost perfect degree of exactness.

Traversing with the Stadia.—In a combination of hydrographic and topographic work, such as the traversing of lakes and other bodies of water, the party usually consists of surveyor, transit-man, two rodmen, and canoe. The traverses of a lake or other body of water is usually made from one or more instrument-stations at or near the shore, the rodman following the bank and giving side-shots at suitable distances apart. For rivers and lakes there is an advantage in keeping one rodman on each side and surveying both sides at the same time, the rodmen following the shore in opposite directions till they meet at the far side. The survey will, however, generally be made on one side only, the front rodman travelling away from the surveyor, while the rear rodman travels towards the surveyor. The rear rodman having reached the surveyor and the front rodman the next instrument station, the surveyor moves his instrument to the next station, while the rodmen are waiting in their places. Upon the arrival of the surveyor the front rodman shows him his new station and the instrument is set up. The rear rodman places his rod upon the last station for orienting the transit, and the survey proceeds as before. It is well to remember that

when the sun is shining and the distance is great, a rod cannot be read unless the sun is shining upon its face, and so only one of the rods can be used for measuring side-shots, according to the direction of the sun. The rodman who is not giving side-shots along the shore can be engaged taking soundings from the boat, while he also gives side-shots to stations on islands.

When no astronomical observation is taken, the instrument is oriented by means of the compass, or rather by the magnetic needle, reading the azimuth of magnetic North deduced from previous readings or from astronomical observations taken from a magnetic map.

It is highly important for the rodman to understand the significance of holding the rod vertical; to ascertain if it is hidden; and how to select a new instrument station. The face of the rod should be turned slightly towards the sun when by so doing the sun can be made to shine on the graduations. A system of signals should be arranged with the rodmen for directing them to stop, or to start again, or to indicate that the rod is hidden. Some signals can be made with the arms, or a flag may be necessary at great distances. Before the rodman leaves the instrument it is well to indicate to him as nearly as possible where the next station is to be. It is more important that the surveyor himself act as front rodman, or at least be with him at instrument points or stations, and leave the transit-man at the instrument. I is also well to read the three wires for both the front and rear instrumental stations as a precaution against errors.

When the instrument is but a few feet above the water it is not necessary to record vertical angles along the shore; when, however, the inclination exceeds 1°-30′, the vertical angle should be recorded and the proper correction applied to the distance read between instrument stations always, and frequently on side-shots if the vertical angle is large.

Reading the Rod.—For reading distances, set the lower wire on an even chain or foot-division on the rod, count the number of feet, tenths and hundredths to the upper wire and estimate the fraction. Distances read by means of the whole interval are twice as accurate as with the half-intervals. The length of courses between stations should always be measured with the whole interval when the distance is less than 1,300 feet, or 20 chains; the readings with the half-interval will necessarily have to be made at distances greater than 20 chains, as the limit of any 13-foot rod is but 1,300 feet with the whole-interval reading, and 2,600 feet reading with the half-interval. When the sum of the readings of the half-intervals equals the reading of the whole interval, the check is significant. The constant of each instrument is anywhere between one and two feet, and this sum must be added to the reading.

As an example of instrument No. X., for which the wire interval factors are: Upper interval 197.19, lower interval 211.53, whole interval 102.18; a reading of 200 ft. with the upper interval corresponds to 197 ft., to which has to be added the constant. With the whole interval, a reading of 1,000 ft. corresponds to 10.22 + .02 (constant). A reading of 2,000 ft. with the lower interval corresponds to 21.15, to which the constant .02 must be added. The correction to the reading is, therefore, + 115 + 2, or + 117; that is to say, the reading both of the rod and the constant is 117 greater than the actual distance.

These directions are tabulated and used for plotting when extreme accuracy is demanded. Usually they may be overlooked. In inclined sights the reductions of distance may be quickly reduced by means of the slide-rule. When the difference between the starting and closing corners differs more than 5 % from the distance in an original survey, if any, the error should be located by retracing with the stadia.

For Soundings.—For obtaining contour lines on lakes, or shore lines 5 ft. deep, 10 ft. deep, etc., procure a quarter-inch hemp rope, attach a 2 or 3-lb. lead to the end and mark every 10-ft. with a strip of red and every 5-ft. with a strip of blue bunting. Always tie the loose end of the rope to the boat before leaving the shore. Soundings can be made in shallow water with the rod, though this method of taking soundings is not recommended. After completing the survey of a lake enter in the notes the nature of the water, whether fresh or alkaline, the sources of supply, the outlet, and such other

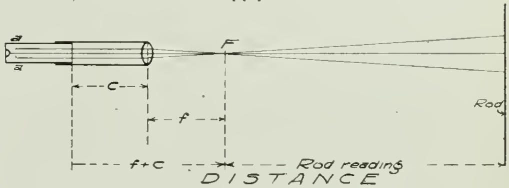


Fig. 1.

data as may be of interest. A determination of the magnetic meridian should be made if the weather permits making an astronomical observation, but this will not always be necessary.

Plotting the Survey.—A rough sketch of the survey should be made or plotted on the right-hand page of the field book before leaving the locality, or as the work proceeds. Two field books may be used consecutively, one being left in the office or camp while the other is in use on the survey. Make the plot, first, at least, in pencil, preferably on paper ruled to a scale of 10 chains to the inch. Commence plotting carefully the instrumental stations and work in pencil the north and south points of each station.

Plot the side-shots by means of the protractor. Then enter on the plan the soundings taken, and all other information that has been collected.

The Field Book.—The left-hand page of the field book is for the notes; the right-hand page for a sketch of the survey. Two stations are designated by numbers; the side-shots by letters. In the first column of the left-hand page enter the letter of the side-shot or the number of station sighted upon. The second column is for the distance read or estimated; the third column for the bearing; the fourth column for the vertical angle, and the remainder of the page for remarks.

Stat. No. or side-shots.	Distance.	Bearing.	Vert. angle.	Remarks.
(1)	...	....	....	Inst. set Comp. north.
(a)	150	307.00	6.40	Top of bank.
(b)	350	115.30	82.45	Foot of bank.
(c)	457	31.25	....	....
(d)	1423	224.51	....	Creek, 10 feet wide, 2 feet deep.
(2)	1343	122.26	85.50	Marshy shore. Water—
Stat. 2—				
(e)	918	46.40	....	....
(f)	987	238.12	....	....
(g)	1423	224.51	....	....

At each instrument-station enter in the notes the nature of the shore, the rise of the ground from the water's edge, the depth of the water as determined from soundings in the boat by one of the rodmen, the estimated distance to the foot or top of the slope when the lake lies in a valley, and such other data as may be considered useful.

SAND SPECIFICATIONS.

In connection with the conclusions arrived at by the Engineering Experiment Station of the University of Illinois, following the extensive tests to ascertain the mortar-making qualities of various sands, the specifications, given below, are proposed:—

It is generally acknowledged that the specifications most frequently used for sand are inadequate in that they are too brief or two indefinite to secure the desired results. Recent specifications have overcome these defects in some respects, but most of them are objectionable in that they are too inflexible, i.e., fail to allow variations in the quality of the sand to meet varying conditions or different requirements, or else by placing undue stress on some particular requirement bar from use sands which would prove entirely satisfactory. The following specifications have been prepared with the idea of giving this necessary flexibility and at the same time making them sufficiently rigid. It is not intended, however, that these specifications should be used indiscriminately for all purposes, but rather that they should serve simply as a guide in preparing the specifications for any particular piece of work. In preparing these specifications both the specifications proposed by the national engineering societies and the results of the test described in the bulletin have been taken as guides.

Definition of Sand and Screenings. — The term "sand" shall be understood to mean natural sand which will pass, when dry, a screen having ¼-in. clear openings. Similar material which is the product of artificial crushing shall be known as "screenings," and shall conform to the specifications for sand.

Suggested Classification of Sands.—Sands shall be classified as No. 1, No. 2, No. 3, plastering sand, and grout sand, the several grades being suitable for the following classes of work:—

No. 1 sand is that required in reinforced concrete and in other work requiring a mortar of maximum strength and density.

No. 2 sand is that required in work not demanding maximum strength or density, but still requiring a mortar of high quality.

No. 3 sand is that required where high strength or density is not a controlling factor.

Plastering sand is that for use in ordinary plastering over masonry, concrete, and wood or metal lath. Either No. 3 sand or plastering sand is of high enough quality for use in lime mortars. The latter sand should be used where the thickness of the mortar joint is such as to require grains of small size.

Grout sand is that for use in pavement fillers and other work requiring a thin, smooth, free-running grout.

Specifications for No. 1 Sand.

Composition.—No. 1 sand shall consist of grains from hard, tough, durable rocks, and be free from soft, decayed, or friable material.

Cleanness.—The sand must be free from lumps of clay, loam, or other foreign material. It shall not contain more than 2 per cent. by weight of finely divided clay, loam, or other suspended matter when tested by washing in such a manner as to remove all such material without removing any of the finest sand; provided, that if the strength of the mortar made from the sand is greater than 110 per cent. of the strength of a similar mortar made with standard Ottawa sand, the amount of suspended matter may reach 3 per cent. This suspended matter must not form a coating around the grains to such an extent that such coating is not entirely broken up and removed from the grains by sprinkling with water or in the mixing of the mortar or concrete. The sand shall be free from oily or greasy matter in any form and must contain no organic silt.

Roughness.—The grains shall have rough, unpolished surfaces to which the cement paste will readily adhere.

Size of Grains.—The grains shall be well graded in size from the finest to the coarsest. For the greatest density not more than 8 per cent. by weight, including the suspended matter, shall pass the No. 100 sieve, and not more than 60 per cent. the No. 16 sieve. If maximum density is not essential and the mortar yields the required strength, these quantities may be increased to 12 per cent. and 75 per cent., respectively.

Voids. — The voids in the dry sand, when well shaken, shall not exceed 33 per cent. of the total volume of the sand.

Tensile Strength.—Mortar, in the proportions of 1:3 by weight, when tested at an age of 28 days, shall develop a tensile strength at least equal to the strength of a similar mortar made of the same cement and standard Ottawa sand tested at the same age.

Specifications for No. 2 Sand.

General Requirements.—No. 2 sand shall meet the requirements for No. 1 sand in all respects except as follows:—

Cleanness.—The suspended matter shall not exceed 6 per cent. by weight when tested in the same manner as described for No. 1 sand.

Size of Grains.—Not more than 15 per cent. by weight, including the suspended matter, shall pass the No. 100 sieve, and not more than 80 per cent. the No. 16 sieve.

Voids.—The voids shall not exceed 35 per cent. of the total volume.

Tensile Strength.—The tensile strength shall equal at least 80 per cent. of that of the standard Ottawa sand mortar when tested as described for No. 1 sand.

Specifications for No. 3 Sand.

No. 3 sand shall meet the requirements of No. 2 sand, except that the suspended matter may reach 8 per cent. and the tensile strength be as low as 65 per cent. of that of the standard Ottawa sand mortar.

Plastering sand shall meet the requirements for No. 3 sand in all respects, except that for the finishing coat it shall be of the requisite fineness to give the desired finish.

Grout sand shall meet the requirements for No. 3 sand except as follows:—

It shall all pass a No. 16 sieve. The voids shall not exceed 38 per cent. of the total volume. The tensile strength shall be at least 40 per cent. of that of the standard Ottawa sand mortar.

The firm previously known as the Caradian Contractors, Limited, of Winnipeg, has recently changed its name to "Joseph Macdonald and Company, Limited."

SPECIFICATIONS FOR DRAIN TILE.

Among the committee reports that were presented at the recent convention in Atlantic City of the American Society for Testing Materials, that of Committee No. C-6, on standard tests and specifications for drain tile, contained something more definite and valuable than has heretofore been published. The following considerations, relating to strength tests, quality and recommended practice in design and construction are extracted therefrom:

Proposed Specifications for Strength Tests.—1. The specimens shall be unbroken, full-size tile. They shall be carefully selected so as to represent fairly the quality of the tile.

2. A standard test shall comprise five individual tests. The result for each specimen and the average of the five shall be given in the report of the test.

3. The materials of the tile shells shall, at the time of testing, be in a thoroughly wet condition, such as may be obtained by covering with sacks kept wet for 8 hours.

4. No test specimen shall be exposed to water or air temperatures lower than 40° F. from the beginning of artificial wetting until tested. Frozen tile shall be completely thawed before artificial wetting begins.

5. Each specimen shall, if practicable, be weighed on a reliable scales just prior to testing.

6. The load shall be applied by any machine or hand method which will apply the load continuously, or in uniform increments not exceeding 0.05 of the total load necessary to break the tile. The tile shall not be allowed to stand any considerable time under load. All solid parts of the bearing frames or bearing blocks shall be so rigid that the distribution of the load shall not be appreciably affected by the deflection of any part. All bearings and the test specimens shall be so accurately centered as to insure in every direction a symmetrical distribution of the loading on each side of the centre of the tile.

7. The inspector, in specifying test requirements for drain tile, shall prescribe in advance one of the three following kinds of bearings: sand bearings; hydraulic bearings; three-point bearings.

8. The test results shall be reported in terms of the ordinary supporting strength. This term shall be defined to mean the supporting strength of a tile when the load is applied with such a distribution as to produce a maximum bending moment of $0.20 \frac{RW}{12}$, where W = the ordinary supporting strength, and R = radius of middle line of tile shell, in inches. The ordinary supporting strength shall be obtained by multiplying the test breaking loads, by the following factors: For sand bearings, 1.00; for hydraulic bearings, 1.25; for three-point bearings, 1.50.

The ordinary supporting strength shall be reported in pounds per linear foot.

9. The modulus of rupture shall be calculated from the maximum bending moment prescribed in Section 8 by the formula

$$p = \frac{6M}{t^2}$$

where p = modulus of rupture in pounds per square inch, M = maximum bending moment in shell in inch-pounds per inch of length, calculated as prescribed in Section 8, and t = thickness of tile shell in inches.

Five-eighths of the weight of the tile per lineal foot for sand bearings, or three-fourths for hydraulic or three-point bearings, shall be added to W in computing the maximum bending moment, when such addition exceeds 5 per cent. of W.

10. Where sand bearings are used, each specimen shall be accurately marked in quarters, with pencil or crayon lines, prior to the test. Specimens shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the pipe, measured on the middle line of the pipe shell. The depth of bedding above and below the pipe at the thinnest points shall at each place be equal to one-fourth the diameter of the pipe, measured between the middle lines of the pipe walls.

The sand used shall be clean sand which will pass a No. 4 screen.

The top bearing frame shall not be allowed to come in contact with the pipe or with the test load. The upper surface of the sand in the top bearing shall be carefully struck level with a straight edge, and shall be carefully covered with a heavy, rigid, top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of uniformly distributing the test load without appreciable bending. The test load shall be applied at the exact centre of this top bearing plate, in such a way—either by the use of a spherical bearing or by the use of two rollers at right angles—as to leave the bearing free to move in both directions. In case the test is made without the use of a machine, and by piling on weight, the weight may be piled directly on a platform resting on the top bearing plate, provided, however, that the weight is piled in such a way as to insure uniform distribution of the load over the top surface of the sand.

The frames of the top and bottom bearings shall be composed of timbers so heavy as to avoid appreciable bending by the side pressure of the sand. The frames shall be dressed on their interior surfaces. No frame shall come in contact with the pipe during the test. A strip of soft cloth may be attached to the inside of the upper frame on each side along the lower edge to prevent the escape of sand between the frame and the tile.

11. Where hydraulic bearings are used, each specimen shall be accurately marked in halves, with pencil or crayon lines, prior to the test.

A hydraulic bearing shall be composed of a wooden platen to which is attached, as hereinafter described, a section of rubber hose. The hose shall lie against the tile, and the pressure shall be applied to the hose through the platen.

The platen shall be built of yellow pine, and shall be at least 4 by 4 in. in section, and its least length shall be the length of the pipe plus 8 in. One-inch quarter rounds with their convex surfaces facing shall be firmly attached to each edge of one side. The straight portion of this face shall extend at least the length of the pipe, and the platen beyond this length may be cut to the arc of a circle.

Between the quarter rounds shall be laid a piece of 2½-in. hose, which shall be closed in a water-tight manner at each end by clamps. The hose shall contain a volume of water not less than one-half nor more than two-thirds its capacity, when completely distended. This hose may be attached to the platen at either end in any satisfactory manner which will not induce wrinkling when under test pressure.

The test load shall be applied at the exact centre of the top bearing, in such a way as to leave the bearing free to move in the vertical plane of the axis of the pipe.

It is recommended that stops be screwed to the platen symmetrical with the point of application of the load, and at a distance apart not greater than the length of the tile plus ½ in. This will help centre the load coming upon the pipe.

12. Where three-point bearings are used, each specimen shall be accurately marked in halves, with pencil or crayon lines, prior to the test.

The lower bearings shall consist of two wooden strips having a corner rounded to a radius of approximately ½ in. They shall be straight and shall be securely fastened to a rigid block in a position such that the bearing lines of a cylinder of 24-in. diameter laid along the rounded edge of the strips shall be 2 in. apart.

The upper bearing shall be a wooden block, straight and true from end to end.

The test load shall be applied through the upper bearing block in such a way as to leave the bearing free to move in a vertical plane passing between the lower bearings.

In testing a tile which is "out of straight," the lines of the bearings chosen shall be from those that appear to give most favorable conditions for fair bearings.

Proposed Specifications for Quality.—1. Specimens to be tested shall be selected by the inspector from the tile to be used on the work; these specimens to be selected at the factory, shipping destination, or at the trench location. The tile shall be measured, sounded and examined by inspection. Five specimens of each materially different class noted shall be selected for a test. If, in the judgment of the inspector, it is necessary either before or after the testing of the specimens, additional specimens may be selected, but in no case shall these additional specimens exceed 1 ft. in length for each 100 linear feet of tile to be laid. These additional specimens shall be furnished by the contractor free of charge at the point of selection, provided that, in case the specimens tested meet the specifications, not more than 1 per cent. shall be required to be furnished free.

2. Each tile shall be of a cylinderical section, the size being designated by the interior diameter. The average diameter shall not be more than 3 per cent. less than the specified diameter. The maximum and minimum diameters of the same tile or average diameters of adjoining tile shall not differ more than 80 per cent. of the thickness of the wall.

3. The minimum length of the tile shall not be less than 12 in. In tile 12 in. or above in diameter, up to 30 in. in diameter, the length shall not be less than the diameter. Tile above 30 in. in diameter need not have a greater length than 30 in.

4. Tile designed to be straight shall not vary from a straight line more than 3 per cent. of its length.

5. Tile shall be reasonably smooth on the inside, and free from cracks and checks extending into the body of the tile in such a manner as to appreciably decrease the strength.

Tile stood on end and tapped with a light hammer when dry shall give a clear ring.

Tile shall be free from chips or broken pieces which will decrease its strength or admit earth into the drain. The end shall be regular and smooth and admit of the making of a close joint when properly turned and pressed together.

6. In a standard test, if one or more specimens fall more than 25 per cent. below the required strength as specified, the class of tile represented by the failing specimens shall be rejected, and other specimens tested to complete the standard test.

7. *(a) Class No. 1B.*—No. 1B tile are intended to be suitable for supporting the load in the worst material in a trench having a grade line 5 ft. deep. They shall have minimum average ordinary supporting strengths calculated as prescribed in Section 8 of the proposed Standard Specifications for Strength Tests of Drain Tile, in accordance with the following table:

Required Average Ordinary Supporting Strength for Class No. 1B Tile.

Diameter of tile, in.	Lb. per linear foot.
10	600
12	700
14	800
16	900
18	1,000
20	1,100
22	1,100
24	1,200

(b) Class No. 1A.—No. 1A tile shall be made of good materials by the most approved method, and are intended to be suitable for supporting the load in the worst material in a trench having a grade line 7 ft. deep.

The inner surface of the tile shall be free from defects. The outer surface shall be free from broken blisters, lumps or flakes which are thicker than 20 per cent. of the thickness of the tile, or whose diameter is greater than 15 per cent. of the inner diameter of the tile, and such defects as are allowed shall not be of such nature as to appreciably weaken the tile when laid in the ditch.

The tile shall have minimum average ordinary supporting strengths (calculated as prescribed in Section 8 of the proposed Standard Specifications for Strength Tests of Drain Tile) in accordance with the following table:

Required Average Ordinary Supporting Strength for Class No. 1A Tile.

Diameter of tile, in.	Lb. per linear foot.
12	900
14	1,000
16	1,200
18	1,300
20	1,400
22	1,550
24	1,700
26	1,800
28	1,900
30	2,000
32	2,050
34	2,150
36	2,250

(c) Class No. 1 Extra A.—No. 1 Extra A tile shall be extra good, and are intended to be suitable for supporting the load in the worst material in a trench having a grade line 10 ft. deep. They shall be either vitrified, salt-glazed, clay tile, or thoroughly seasoned concrete tile, made of the best materials, by the most approved method.

The inner surface of the tile shall be free from defects. The outer surface shall be free from broken blisters, lumps or flakes which are thicker than 16 per cent. of the thickness of the tile, or whose diameter is greater than 12 per cent. of the inner diameter of the tile, and such defects as are allowed shall not appreciably weaken the tile when laid in the ditch.

The tile shall have minimum average ordinary supporting strengths (calculated as prescribed in Section 8 of the proposed Standard Specifications for Strength Tests of Drain Tile) in accordance with the following table:

Required Average Ordinary Supporting Strength for Class No. 1 Extra A Tile.

Diameter of tile, in.	Lb. per linear foot.
12	1,000
14	1,200
16	1,500
18	1,700
20	2,100
22	2,300
24	2,500
26	2,600
28	2,800
30	3,000
32	3,200
34	3,300
36	3,500

8. Tile not meeting the above specifications shall be rejected.

Proposed Recommended Practice in Design and Construction of Tile Drains.—The selection of a class of tile suited to a particular case requires a knowledge of the pressures to which the tile will be subjected. This in turn depends upon the character of the soil and the manner of laying the tile as well as upon the depth and width of ditch. The following is recommended as good practice in design and construction:

Methods of Tile Laying.—1. Three grades of work are recognized, namely, Ordinary, First Class, and Concrete-Cradle. Generally the engineer will specify the grade of work required, but in some cases it may be advisable to allow the contractor a choice between using a superior method of laying, or a stronger tile.

2. In Ordinary tile laying the contractor shall shape the bottom of the ditch approximately to fit the lowest one-quarter of the outside circumference of the tile, taking pains to secure an extra firm bearing near the outer edges of the bearing area.

In hard material he shall bed the tile in a thin layer of granular earth where, in the judgment of the engineer, it is necessary to secure a good bearing.

After the tile is bedded truly to line and grade, the contractor shall carefully place the earth around and over the tile by hand to the depth of at least 1 ft. over the tile, using shovels or other suitable tools to work the earth filling down the sides, and underneath the tile so far as practicable.

Whenever the ordinary supporting strength of the tile, as determined by actual tests, and calculated as prescribed in Section 8 of the proposed Standard Specifications for Strength Tests of Drain Tile, is 50 per cent. or more in excess of the strength specified, the bottom of the ditch need not be shaped to fit more than the lower one-eighth of the outside circumference of the tile.

3. In First-Class tile laying in hard material, the contractor shall shape the bottom of the ditch approximately to fit the lowest one-quarter of the circumference of the tile, taking pains to secure an extra firm bearing near the outer edges of the bearing area. Upon the concave surface so prepared the contractor shall spread a layer, 1 to 2 in. thick, of pulverized soil, or sand free from pebbles larger than ¼ in. diameter, and shall firmly bed each tile truly to line and grade thereon.

Where the bottom of the ditch is so wet and soft as to enable the thorough bedding of the lowest one-quarter circumference of the tile without the use of the layer of pulverized earth or sand, and still is firm enough to afford good, safe support to the tile and its load of ditch filling, the engineer may authorize the omission of the layer of granular material, but such authorization shall not excuse imperfect bedding.

The space between the tile and the bottom and sides of the ditch shall be filled with selected earth, thoroughly tamped as fast as placed, up to the level of the top of the tile. The side filling shall be carried up as rapidly on one side of the tile as on the other.

The tile shall then be covered by hand with earth to a depth of at least 1 ft. above the top of the tile.

No tile laying shall be considered as First-Class unless the laying and tamping of each tile are watched and directed by an inspector kept constantly on the work for that purpose.

4. Two grades of Concrete-Cradle tile laying shall be recognized, one for solid material and the other for yielding material.

(a) Solid Material.—Solid material shall be defined as that which is as solid as average, firm, clay sub-soil. Concrete-Cradles, Solid Soils, shall be made as follows:

The contractor shall shape the bottom of the ditch to fit approximately the lowest one-fourth of the circumference of the tile. Upon the concave surface so prepared there shall be spread at least 2 in. of soft concrete, stiff enough to sustain the weight of the tile, and the tile shall be firmly bedded truly to line and grade thereon.

The space between the tile and the bottom and sides of the ditch shall then be thoroughly tamped or spaded full of soft concrete, up to a level one-quarter of the diameter of the tile above the mid-height. The thickness of the concrete at any point shall not be less than 2 in.

Each joint shall be promptly cleaned on the inside of the tile, as soon as the concrete is in place for that joint.

The concrete used in this method of strengthening tile shall be made of 1 part Portland cement and 8 parts of gravel, or 1 Portland cement, 5 parts sand, and 8 parts broken stone. No pebbles or stone shall exceed in size 1 in. less than the thickness of the concrete.

(b) Yielding Materials.—Yielding materials shall be defined as including all materials not solid, as defined above.

Concrete-cradles for yielding material shall be designed by the engineer to carry safely to the soil foundations both the vertical load on the tile from the ditch filling and a side thrust at the mid-height of the tile, such as would exist if the tile were cracked at the top, bottom and each side. The thickness of the concrete at the lowest part of the bottom of the tile shall be at least one-eighth, and on each side at the mid-height at least one-fifth the internal diameter of the tile, and the side concrete shall extend about one-quarter of the diameter above the mid-height of the tile. Each joint shall be promptly cleaned on the inside of the tile as soon as the concrete is in place for that joint.

The concrete used in this method of strengthening pipe shall be made of 1 part of standard Portland cement and 5 parts of good, coarse, clean gravel, or 1 part of standard Portland cement, 3 parts clean, coarse sand, and 5 parts broken stone. No pebbles or stone shall exceed 2½ in. in greatest diameter, nor exceed 1 in. less than the thickness of the concrete.

5. Tile in the trench shall not be subjected to freezing weather during construction without a sufficient depth of cover to prevent cracking.

6. In Table I. are given the approximate values in pounds per linear foot of the ordinary maximum loads on drain tile and sewer pipe from common ditch-filling materials, as determined by tests[1] at Ames, Iowa, and Bos-

[1] For both the tests and the data of actual drains and sewers, see the Report of Committee C-6 on the Investigations on Drain Tile, American Society for Testing Materials, published as Bulletin No. 36, Iowa Engineering Experiment Station.

ton, Mass., and by study of the detailed data of about 90 actual tile drains and pipe sewers, part sound and part cracked.

It is recommended that for clay and all common material except sand and loam, the values under clay be used, and for sand and loam, the values under sand.

Strength of Tile Required.—6. It is recommended that where tile are to be laid according to the description for the Ordinary method, a factor of safety of 1½, applied to the average strength, shall be used when the results of the tests are reported in terms of the ordinary supporting strength, calculated as prescribed in Section 8 of the proposed Standard Specifications for Strength Tests of Drain Tile, and loads estimated according to Table I.

7. Where the tile are to be laid in accordance with the method denominated First-Class, in consideration of the increased support furnished by the improved foundations, the nominal factor of safety to be employed shall be 1¼, applied to the average strength, and with loads estimated according to Table I.

8. In this case it is intended that the concrete-cradles shall furnish the strength necessary to carry the load from the ditch filling. It is recommended, however, that only Class No. 1 A or Class No. 1 Extra A tile shall be used in this case.

Table I.—Maximum Loads on Drain Tile and Sewer Pipe from Ordinary Ditch-Filling Materials—Ordinary Sand, 120 lb. per Cu. Ft.; Thoroughly Wet Clay, 120 lb. per Cu. Ft.

Loads in Pounds per Linear Foot.

Height of fill above top of tile, ft.	Breadth of Ditch a Little Below Top of Tile: 1 ft. Sand.	1 ft. Clay.	2 ft. Sand.	2 ft. Clay.	3 ft. Sand.	3 ft. Clay.	4 ft. Sand.	4 ft. Clay.	5 ft. Sand.	5 ft. Clay.
2	180	190	410	420	650	660	890	900	1,110	1,130
4	270	300	710	750	1,170	1,220	1,640	1,690	2,100	2,150
6	310	360	910	1,000	1,590	1,680	2,270	2,400	2,970	3,100
8	340	400	1,070	1,190	1,910	2,070	2,820	3,000	3,720	3,930
10	350	420	1,180	1,330	2,180	2,400	3,260	3,510	4,380	4,680
12	360	440	1,250	1,440	2,400	2,670	3,650	3,990	4,980	5,340
14	360	440	1,310	1,530	2,570	2,890	3,990	4,380	5,490	5,940
16	360	450	1,350	1,600	2,710	3,090	4,260	4,740	5,940	6,480
18	360	450	1,380	1,650	2,820	3,250	4,490	5,050	6,330	6,930
20	360	450	1,400	1,690	2,910	3,390	4,700	5,340	6,660	7,410
22	360	450	1,420	1,720	2,980	3,510	4,880	5,570	6,960	7,800
24	360	450	1,430	1,740	3,050	3,600	5,010	5,780	7,230	8,160
26	360	450	1,440	1,760	3,090	3,680	5,150	5,970	7,460	8,490
28	360	450	1,440	1,780	3,120	3,750	5,240	6,120	7,670	8,760
30	360	450	1,440	1,790	3,150	3,800	5,340	6,280	7,830	9,030
Infinity	360	450	1,450	1,820	3,270	4,090	5,820	7,280	9,090	11,370

PROPOSED STANDARD ROAD TERMS.

By the Committee on Standard Tests for Road Materials, appointed by the American Society for Testing Materials, the following terms applicable to materials for roads and pavements were submitted at the recent convention of the society as proposed standard definitions:

Asphalts.—Solid or semi-solid native bitumens, solid or semi-solid bitumens obtained by refining petroleum, or solid or semi-solid bitumens which are combinations of the bitumens mentioned with petroleums or derivatives thereof, which melt upon the application of heat and which consist of a mixture of hydrocarbons and their derivatives of complex structure, largely cyclic and bridge compounds.

Asphaltenes.—The components of the bitumen in petroleum, petroleum products, malthas, asphalt cements and solid native bitumens, which are soluble in carbon disulphide but insoluble in paraffin naphthas.

Blown Petroleums.—Semi-solid or solid products produced primarily by the action of air upon originally fluid native bitumens which are heated during the blowing process.

Carbenes.—The components of the bitumen in petroleums, petroleum products, malthas, asphalt cements and solid native bitumens, which are soluble in carbon disulphide but insoluble in carbon tetrachloride.

Cut-back Products.—Petroleum or tar residuums which have been fluxed with distillates.

Tars.—Bitumens which yield pitches upon fractional distillation and which are produced as distillates by the destructive distillation of bitumens, pyrobitumens or organic materials.

Coal Tar.—The mixture of hydrocarbon distillates, mostly unsaturated ring compounds, produced in the destructive distillation of coal.

Coke-oven Tar.—Coal tar produced in by-product coke ovens in the manufacture of coke from bituminous coal.

Dehydrated Tars.—Tars from which all water has been removed.

Gas-house Coal Tar.—Coal tar produced in gas-house retorts in the manufacture of illuminating gas from bituminous coal.

Oil-gas Tars.—Tars produced by cracking oil vapors at high temperatures in the manufacture of oil gas.

Pitches.—Solid residues produced in the evaporation or distillation of bitumens, the term being usually applied to residues obtained from tars.

Refined Tar.—Tar freed from water by evaporation or distillation which is continued until the residue is of desired consistency; or a product produced by fluxing tar residuum with tar distillate.

Water-gas Tars.—Tars produced by cracking oil vapors at high temperatures in the manufacture of carburetted water-gas.

Editorial

JOHN GALBRAITH, ENGINEERING EDUCATIONALIST.

With engineering in Canada will always be prominently associated the name of John Galbraith, who gave the fullness of his life to the building up of an institution devoted to the teaching of the scientific principles which, when inculcated, formed the basis of many engineering careers. The loss which engineering has sustained at his death will never be fully realized. So brightly has shone the personality of the Dean through so many years that it will continue to shine.

Nearly forty years of a whole-hearted application of one of the most observing, resourceful and judicious intellects, to the problems before it, have left an impress that nothing can obliterate. His tremendous ability, his remarkable alertness to the difficulties of others and to the cause to which he had devoted his life, his unceasing vigilance and prompt yet cool and masterful disciplinary powers, his keen sympathies for the student and his work, for his staff and its worries, for the country and its needs, raised him high above his fellow men, yet nestled him into their hearts.

The encomiums which are being so abundantly and so deservedly accorded him, come with double aptitude, in the light of the fact that death found him in the harness, to the last, never lingering, never slipping, and always in the hearts of his School men, always with them in his heart.

ETHICS IN COMPETITIVE DESIGN.

Competitive designing may be a good thing, providing the rules of the game are observed. Its goodness is altogether contingent, however, upon close adherence to the conditions by which the competition is governed. Otherwise it is apt to come within the category of "skin games."

Recently the council of a western city took a flier into the sport and launched a competition, which is very slow at righting itself to the general satisfaction of all concerned. For even the judges should observe the rules with exactness.

The city employs an engineer. (It may be that our readers will remember a reference in these columns last year to a city engineer, taken suddenly ill, being indiscreet enough to be hustled to the hospital without first bending his knee and asking permission—thereby almost forfeiting his job. It is the same city engineer, and the same city. The incident was commented upon to show the absolute lack of fairness which the city council displayed in dealing with the case.)

Competitive designs were received this spring for a piece of engineering work of interest to engineers and architects. The conditions of the competition, with which we are especially concerned, stipulated that the competitors were required to submit fully detailed drawings to enable the city engineer to check over the design, as regards strength and stability, as well as specifications, quantities, prices, etc.; that designs were required to conform in line and grade with location plans supplied by the city engineer, and that, should any of the conditions be ignored, the plans, being disqualified, would not receive consideration.

Some 29 designs were submitted by 23 engineers and architects. They were referred to the city engineer. The city engineer also prepared a design, which, it is stated, was not presented at the same time as the others. Later he prepared a second design.

The special committee of the city council took his design No. 2 into competition with the others and recommended it.

The other competitors thereupon held a meeting and protested against the recommendation on the grounds that, (1) the city engineer acted in a triple capacity, viz., as compiler of the regulations governing the competition, as technical expert in judging the designs, and as a competitor; (2) the city engineer's design was contrary to his own regulations, and did not conform to the lines and grades as laid down by himself. Therefore it was not eligible for competition. Having spent considerable time, labor and money on the competition, the competitors (21 of whom had signed the protest) hoped that the council would take a stand which would allow it to be closed with satisfaction to all and honor to the council.

The city has a branch of the Canadian Society of Civil Engineers, who protested against the procedure; so did the Provincial Architectural Institute.

The city council adopted the design No. 2 submitted by the city engineer.

In view of the disturbance which resulted from the proceedings, the city engineer, in a letter to the mayor, stated that the modification of design No. 1, which was embodied in design No. 2, had been conceived and prepared before examining the individual plans submitted by the various competitors. He explained that the choice of design was not made by him or upon his recommendation but by the committee; and that he was not present when the decision was reached. He made it clear that since his own designs were in competition with the other twenty-three, he would prefer to be relieved of all responsibility for advising the city council in the matter.

It is stated, further, by one of the aldermen, that no one knew of the design No. 2 until a day or two before the committee met to go over the plans. According to the city engineer's letter to the mayor, his report dealing with the engineering features of the various plans had been prepared prior to this. The sub-committee to go over the plans and city engineer's report was not appointed until six weeks after the competition had been closed. It is very evident that as the city grows older its council is not improving in the matter of fairness. But there is an engineer connected with the unfairness, whose case should be clearer than the circumstances indicate. We have been hoping that our information is inaccurate, but supplementary advices from other sources strongly bear it out. Is it a case of absolute devotion to his employers, in right or wrong, with an equally absolute disregard for engineering ethics?

JOHN GALBRAITH

DR. JOHN GALBRAITH, Professor of Engineering and Dean of the Faculty of Applied Science and Engineering, University of Toronto, died at Go Home, among the islands of Georgian Bay, on July 22nd, 1914. It was known by an intimate few that his health had been seriously impaired, but death came with appalling and unexpected suddenness, even to the members of his family close to him at the time.

His early career, until the founding of the School of Practical Science in 1878, is briefly told. Born in Montreal, September 5, 1846, and coming with his parents a few years later to reside in Ontario, his early and high school education was received in Port Hope. At the age of 17 he entered the University of Toronto. Here, despite his modest and retiring nature, his desire for a liberal education, and for the uplifting of others as well as of himself, created a pronounced interest in undergraduate activities. The annals of the University record him as a participant in the foundation of several of the earlier organizations, including the first National Science Club.

His graduation with the degree of B.A. was marked by a singular appreciation of his ability, in the award to him of a double scholarship in mathematics and general proficiency. He acquired the gold medal in the former, and in 1868 his unparalleled qualifications earned for him the Prince of Wales' prize. Characteristic of the genius and of his insatiable desire for knowledge, the education which had been accompanied by these distinctions was regarded by him as very ungratifying. Though young in years, he had a remarkable conception of the future of the country and of its inevitable development. His explorations into the forest-covered confines of Upper Canada had revealed to him the dependency of this development upon the training in applied science of young men. Throughout the years which followed his convictions were augmented by the primitiveness of many of the methods then in vogue in engineering work. During his connection with the building of the Midland, the Intercolonial and the Canadian Pacific railways his resourcefulness and comprehensive grasp of fundamentals earned for him the prophecy of his chiefs, that in the open field of civil engineering his would be a most notable career. But the yearning for the application of science to the problems of engineering triumphed over the call of the wild. In 1875 he returned to the University of Toronto for the degree of M.A. and strongly voiced his convictions, now a part of himself, that the direst need in education at that time was the need of a technical training for young men, to enable them to become engineers. His persistent and potent arguments resulted in the Legislative Assembly of 1877 sanctioning the establishment of a School of Practical Science in Toronto. His scheme of organization included an arrangement whereby the students of the proposed institution were to enjoy full advantage of the instruction given by the teaching staff of University College in all the departments of science which would be embraced in the work of the School. John Galbraith assumed the full personal responsibility of instruction in Engineering Thus opened the gateway through which have passed a multitude of technically trained engineers—one of the outstanding and epoch-making events in the history of the Dominion of Canada.

The progress of the School of Practical Science through the intervening years, until 1906, and its development since, as the Faculty of Applied Science and Engineering of the University of Toronto, is as well and truly written over, and under, the surface of this country as it is in the archives of Parliament or the University. Better! It bespeaks, as writings cannot do, the long-drawn strife and indefatigable devotion of the force behind the institution. The history of the institution is the biography of the man. Its success has been to his sacrifice. The story of the battle of a life-time will never be told in full. The conscientious engineer carried his self-unrevealing troubles under seal to his grave.

The arduousness of the academic work which he had set himself to do, took him, during the summer months of each year, into the field of engineering to acquire first-

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Dr. Galbraith was one of the greatest men of his age, for he has been instrumental in producing the men who are now so strong a factor in the development of our Dominion.

I shall always cherish his memory with sincere affection.

H. G. Tyrrell, '86,
Consulting Engineer.

Evanston, Ill., July 24th, 1914.

Dean Galbraith was the greatest practical engineering educator of his time and, through his graduates, he has influenced all parts of the engineering world. I count it a great privilege to have studied under him, and the friendship which has since continued makes me mourn his loss most keenly.

Louis L. Brown, '95,
Vice-President The Foundation Co.

New York, July 25th, 1914.

Dean Galbraith possessed, I believe, more of the Christian virtues than any other man I have known. He was of a most kindly disposition and was considerate, almost to a fault, of the feelings of all with whom he came in contact.

For over twenty years he has been my most intimate friend, and in this long period I cannot recall his ever having spoken uncharitably of anybody, although he occasionally expressed righteous anger at manifest wrong doings. He practiced to the fullest extent the Golden Rule, "Do unto others as you would have others do to you."

He was extremely happy and content in his home life and had practically no outside interests, other than those connected with the University and the School of Science.

R. F. Stupart,
Meteorological Service.

Toronto, July 25th, 1914.

hand knowledge of its progress and its requirements. Always on the alert, years went by with no cessation of engineering activity. His extensive knowledge of the geographical and geological nature of the country was acquired by canoe and trail, years before the faces of other white men had penetrated into the Indian's domain. The various tribes committed their dialects to his mastering, his friendships among the red men were many, and more than one tribe has hailed him as the "Chief of all the Whites." His foot trod over the mineral fields between civilization and Hudson Bay a score of years before the intrusion of the pick, and the northern waterways familiarly bore his canoe when geographical map there was none. He saw it all as a field for the engineer, and as the horizon receded, he saw to it that his purposeful labors, with their attending trials and responsibilities, expanded accordingly. The sun set with his shoulder still to the wheel.

> He has left his mark in Canada through his great influence. He was beloved and revered by every student who studied under him and few men will be more widely mourned.
>
> T. R. Deacon, '91,
> Mayor.
>
> Winnipeg, Man., July 27th, 1914.

A noted writer has already said of him: "In a world where men are crowding and pushful, it is gratifying to see, now and then, a man who is quiet and retiring brought out whether or no, and placed in front, where his attainments entitle him to be." In 1907, he was appointed a member of the Royal Commission to investigate and report upon the collapse of the Quebec Bridge. In 1909 he was elected president of the Canadian Society of Civil Engineers, for which he had long acted as councillor and in the establishment of which, in 1887, he was one of the founders. Back in 1902 the University of Toronto conferred upon him the honorary degree of LL.D., and in the following year Queen's University, Kingston, likewise paid tribute to his ability. For many years he had been an associate member of the Institution of Civil Engineers of Great Britain.

> For 32 years I had the great good fortune of the acquaintance, advice, instruction and friendship of Dean John Galbraith.
>
> The late James Ross, a thorough judge of men, said in 1883, that Galbraith was an exceptionally capable engineer and teacher, and that any boy who was fortunate enough to graduate under his instruction would need no further collegiate training in Europe or America.
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> The advice given me by Dean Galbraith has been repeated to many young men, as I have felt sure that it would benefit them as it has benefited me.
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> There is no man living whom I respect, admire and love as much as I did Dean Galbraith.
>
> T. Kennard Thomson, '86,
> Consulting Engineer.
>
> New York, July 25th, 1914.

In his earlier manhood, Dr. Galbraith was a military as well as a civilian engineer. He was present at the mustering of the garrisons near Montreal in the sixties, upon the occasion of a visit from the then Prince of Wales, later King Edward VII. The story has been told of the call for volunteers during the Fenian raids. At that time he was an assistant on the railway survey party. When news of the call reached the party in the forest, the chief, desirous of enlisting, designed to leave the work in charge of John Galbraith. His assistant, however, advanced his own sense of duty at such a time of need, arguing that the better surveyor should stay and the better fighter should go. The acknowledgment of the respective qualifications was somewhat unbalanced and the latter accomplishment required vindication. This was adjusted out behind the tent. Galbraith went.

To the graduates of the institution known familiarly as "The School," the record of his death has come with appalling suddenness. He was dearly loved by all; by some as the Dean, by others as the Principal, by many others by the more familiar and genuinely brotherly appellation of "Johnny." The age of 67 found him with his energies ebbing, spent in the pursuit of his life-work, to a greater degree than any but his closest friends surmised. After a strenuous year, full of characteristic endeavor to bring his institution to that degree of efficiency that has always been his ideal, he had repaired with his family, only a few weeks ago to Go Home, a quiet and beautiful spot established by himself more than twenty years ago on the shores of Georgian Bay. His lowered

> For a long while I have known him—33 years—and in all that time, first as a pupil and afterwards as one of the many who had the good fortune to possess his friendship, I grew to respect more and more and admire those rare qualities of heart and mind which so endeared him to all who knew him well.
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> His personality was extremely attractive. He appealed to all sorts and conditions of people, to young and old, to the plain workman as well as to the educated college man.
>
> He had all the qualities of a truly great leader. He had wonderful tact and intuition and was very, very kindly. His modesty and genial good nature, keen sense of humor, and charity for human weaknesses, gained him friends everywhere, and yet when necessary, he could be very strong, but he ruled through love and not through force.
>
> He possessed the faculty to a remarkable degree of imparting knowledge to others, and of stimulating a desire for thoroughness. I have met none who were his equal in this respect. There was something in him which unconsciously brought out the best in his pupils. I do not remember that he ever lectured his class on conduct or ethics; but his influence somehow stimulated the best that was in us. He was not only a great teacher of Applied Science—he was an upbuilder of character—he made Men as well as Engineers.
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> His loss to Canada and to the University is very great. To his wife and family and to his many devoted friends, it is irreparable; but he had lived to see the fruition of his life's work, and it gave him much joy in his later years to see the bountiful return which his early strenuous and loyal work had produced. The influence of his life will long survive him. The world is better for John Galbraith having lived.
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> Eugene W. Stern, '84.
> Consulting Engineer.
>
> New York City, July 24th, 1914.

vitality failed, however, to respond, as usual, to the recuperative environments.

Dean Galbraith was not a seeker of renown. His world-wide reputation is of the kind that will wear through ages, gathering as it has done from without the horizon of his sphere of labor. He merely sought to do his part, faithful to himself, loyal to his profession, a friend of every student, and every man a student like himself. With the close of his career the continent loses the person of one of its greatest educators, but one who had accomplished so much in the upbuilding of the engineering profession that the personality behind it all will go down through the ages an archetype of the life of the engineer as it should be lived to do the most good to mankind.

LETTERS TO THE EDITOR.

Concrete Arches.

Sir,—I note with considerable interest, in your issue of June 11th, 1914, the five conclusions drawn from the paper on concrete arches in Proceedings of the American Society of Civil Engineers for Vol. 39, page 1193.

The writer of your article has not referred to the discussion which followed in subsequent numbers of Proceedings. Some recognition of the same should be made, for, in the writer's opinion at least, these discussions, made by the most eminent engineers of the country, are of great value.

As I am at present away from Toronto and have not these numbers of Proceedings with me, I am unable to give names or figures, but the following general discussions are, I believe correct:—

* (1) and (2) are generally confirmed.

(3) This statement is questioned by a large number of engineers. In the first place, there will not be very much more concrete in a fixed rib than in a three-hinged rib, if both are properly designed, and the cost of forms will be very nearly the same. Consequently, the saving in using a three-hinged rib will be only in material, and the estimate should be so prepared. On the other hand, the cost of the hinges is very considerable, and will usually offset, or even outweigh, the saving in concrete.

Secondly—The fixed ring is without doubt more rigid and stable than the hinged ring.

Thirdly—The greater reliability which is attributed to the hinged ring is largely a matter of facility and certainty of design. A fixed ring is susceptible of a very rigid and accurate design, and can be carried to a scientifically fine point. Of course, the labor of designing a fixed arch is somewhat greater than of a hinged arch.

The value of a hinged arch ring is its greater adaptability to small motions of the abutments. But in the general condition of rigid, immovable abutments the fixed ring is generally considered not only better design, but more economical.

Permit me to refer your readers to the last chapter in David A. Molitor's "Kinetic Theory of Structures," which the writer holds in high esteem.

(4) The rib of I-section is not in general favor, since any small settlement which may occur before forms are removed tends to crack off the flanges. (For want of a better word I employ the term flanges, which will at least be understood.)

In addition to this, the extra amount of formwork which is necessitated by this form of arch ring will reduce, or even eliminate, the economy of concrete material.

(5) The value attributed to the form of pier mentioned in the article is also somewhat questioned, chiefly on account of the agitation and obstruction of the current of the stream. This difficulty can, no doubt, be overcome by carrying a solid pier to above high water.

These remarks can be amplified and verified by an examination of the numbers of Proceedings in which these discussions are published. I trust they will be of some interest to your readers.

Ernst G. Kaufmann, C.E.

Schomberg, Ont., July 21st, 1914.

* See *The Canadian Engineer*, June 11th, 1914, page 872.

Improved Roofing Materials.

Sir,—We have read with interest a paper by W. E. King, C.E., published in your July 16th issue under the title of "Economical Design of Industrial Works," and we note therein a paragraph referring to the roof.

We would like to inform your readers that we have had a series of experiments with two styles of roof, which have proven very efficient and permanent. A great many industrial establishments in Montreal and elsewhere in Canada have been covered with a thin slab of fine cinder concrete, ordinary cement mortar, and finished with felt or asphalt material.

The idea of construction is to attach to the roof small shapes for purlins at 5-ft. centres, and to these purlins attach ¾-in. or 1-in. channels at 12-in. centres and transverse, and to these channels apply a 24-gauge expanded metal lathing. To this lathing apply a fine cinder concrete, and when the slab is dry finish the exposed side with a roofing compound and plaster inside with ordinary cement mortar. This makes a permanent roof, and by the use of the two different compounds condensation is reduced to a minimum.

Another very superior style of fireproof and permanent roof is procured by the use of ferro-dovetail plates. The idea is to attach purlins from 4 to 6 ft. centres, and to these purlins attach the plates in the same manner as you would attach corrugated sheets. When these sheets are affixed, cover with cinder or fine stone concrete, applied to a thickness of 1 in. above the plates, and then apply your roofing compound. The underneath side of the plates can then be plastered with ordinary lime mortar, cement mortar or gunite.

The Pedlar People, Limited,
Per W. E. Ramsay.

Montreal, July 17th, 1914.

Two books have been published dealing with the proceedings of the Fifth National Conservation Congress, held in Washington, D.C., last November. One of them treats of Water Power subjects exclusively, and is an important contribution to constructive literature in this subject. The other book contains the Forestry reports and addresses, which were conceded to be the most valuable ever presented at a similar meeting in this country. The books may be had through N. C. McLoud, Treasurer and Recording Secretary of the Congress, 1201 Swetland Building, Cleveland, Ohio.

ENGINEERS' LIBRARY

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer.

CONTENTS.

CONTENTS.

BOOK REVIEWS.

Insulation and Design of Electrical Windings.—By A. P. M. Fleming and R. Johnson. Published by Longmans, Green and Co., London. Canadian Selling Agents, Renouf Publishing Co., Montreal; 224 pp.; 102 diagrams; size 6 x 9 ins.; cloth. Price, $2.25. (Reviewed by Prof. H. W. Price, Department of Electrical Engineering, University of Toronto.)

Relatively there are very few books on insulation which attempt to treat the subject generally. The authors of this volume have offered a valuable addition to this literature, and in it have included a large collection of data in tabular and curved forms on mechanical and electrical properties of insulation for rotating and static electrical machinery. It is difficult to predict with exactness the service to be expected of insulation, because in so many situations it is subjected not only to fairly definitely-known electrical stress and frequency, but also to variable and imperfectly-known punishment or fatigue from mechanical strain in construction and operation, dirt and moisture, overheating, high frequency, etc. Therefore trial and error is largely depended upon for advice. The authors have made many tests to find individual effects of these variables in operating life of insulations, and their results are interesting as an aid toward good judgment in design.

The first three chapters are devoted to an account of physical characteristics of gaseous, liquid and solid dielectrics, the nature and extent of electrical stresses to be met in practical work and properties of many insulating materials when subjected to electrical stress, fatigue from continued over-stress or abnormal frequency, effects of oil and moisture on both electrical and mechanical characteristics, properties when dried out in various ways after abuse, etc. The authors have evidently made many investigations themselves, have also collected data from other sources, and with many curves, tables and discussion, offer a good assembly of information.

A large section is devoted to "design of insulation and windings," insulation tests, etc. Various windings for motors, generators, and transformers are discussed from the insulation point of view, and many sketches are offered showing actual materials and thickness provided for specified service. This information is extensive and valuable, but in view of titles of book and chapter one wonders why no attempt is made to explain how the authors would proceed with their data to choose insulation other than by copy-cut-try methods, which their preface states they desire to make less necessary.

The last two chapters concern drying and handling of windings in factory and in service, and causes of failures in service. Such matters as drying of transformer oil, which have been fully dealt with by others, are given little space. Here, as in several other places in the book, the authors have wisely preferred definite references to their selections from literature now available on the point in question.

Sanitary Engineering.—By Francis Wood, M.I.C.E., F.G.S. Published by Chas. Griffin and Co., Exeter St., Strand, London; 306 pp.; 181 illustrations; size 5½ x 7½ ins.; cloth. Price $2.25 net.

This is the third edition of a practical manual of town drainage, sewerage and refuse disposal. It contains a number of additions covering improvements and alterations, which have developed in the design and construction of sewers, particularly in the application of concrete; also in the ventilation of sewers or oxygenation of the sewage, and other subjects which have been given great attention since the publication of the first edition 13 years ago.

The book contains 20 chapters, the first three of which are of an elementary nature and deal lightly with hydraulics together with formulæ for the velocity of flow in pipes, etc. Following, 12 pages are devoted to a technical consideration of earth pressure and retaining walls. Chapter V. is on power, and a few facts are given concerning water-power, steam, electricity and compressed air. In the reviewer's opinion, the six pages devoted to the subject of power might well have been omitted as the subject matter is so elementary as to be entirely lacking in practical information respecting the subjects mentioned. Mere definitions of horsepower, ohm, ampere, volt, etc., seem quite out of place in a book written specially for the sanitary engineer.

The subject of house drainage has been well and thoroughly treated, both from the standpoint of the urban and rural dwelling. Chapter VII. has to do with land drainage, evaporation, rainfall, etc. The subject of sewers and sewerage systems are taken up in a capable and comprehensive manner in some 70 pages, under the headings of Sewers, Separate System, Sewage Pumping, Sewer Ventilation, Drainage Areas, Manholes, etc. A chapter of 20 pages is devoted to trade refuse and river disposal. The titles of the remaining chapters are Sewage Disposal, Bacterial Treatment, Sludge Disposal, Construction Materials and Cleansing of Sewers, Refuse Disposal, Chimneys and Foundations. The book is well indexed, the illustrations are particularly clear and the whole subject is treated in such a way as to render the book a valuable one to sanitary engineers, architects, inspectors, contractors and students.

Metallurgy of Copper.—By H. O. Hofman, E.M., Met.E., Ph.D., Professor of Metallurgy, Massachusetts Institute of Tecnology. Published by McGraw-Hill Book Co., New York City; 556 pp.; 548 illustrations; 130 tables; size 6 x 9 ins.; cloth. Price, $5 net. (Reviewed by Geo. A. Guess, Metallurgical Engineer, Toronto.)

To write the metallurgy of copper is unquestionably a difficult undertaking. Progress in the art is so rapid, each year seeing new developments, that a book can hardly be written before new metallurgical features are in successful use.

Dr. Hofman in his "Metallurgy of Copper" has, however, given us a book that is up-to-date, and which covers the field as no other book does. The work is essentially a compilation of the published literature on the metallurgy of copper, supplemented by data obtained from several of the larger American smelters and refineries. The work is clear, concise and free from padding. It is difficult to find anything but praise for the book. If inclined to be critical one might object to descriptions and cuts of roasting furnaces hopelessly antiquated, or of descriptions of smelting operations which recall the days when an air of mystery surrounded the metallurgist. Such a description is given in the smelting in of a reverberatory furnace bottom. Under leaching methods considerable attention is paid to wet processes for treating copper mattes, a practice which is extinct in America. It is to be hoped that, in view of the rapid development of wet methods of ore treatment, the author will rewrite in a year or two bis chapter on the leaching of copper ores. The book quite correctly does not deal with any form of wet concentration or flotation. It is written for the profession and the advanced student of metallurgy.

The work is purely descriptive. The author refrains from criticizing furnace or plant design. He states without comment, conditions as they exist, as to equipment of plant, and scheme of operations. He reviews the evidence and leaves the case with his readers.

Practical Iron Founding.—By Jas. G. Horner, A.M.I., Mech. E. Published by Whittaker & Co., London and New York. 409 pages; 285 illustrations; size, 5 x 7 ins.; cloth. Price, $1.25 net.

The principles and practice of iron founding are depicted in this work for the special guidance of the student and of the practical man, relating particularly to the two branches of machine molding and the melting of iron. This is tbe fourth edition of Mr. Horner's treatment of the subject, and it has been thoroughly revised and enlarged to conform with the great changes which the industry has experienced since the first edition was published. In it the portion devoted to machine molding has been entirely rewritten and new chapters prepared with additional examples of molds introduced. The volume has outgrown the stage of elementary treatise and its value has increased accordingly.

Its scope may be briefly summed up by an enumeration of the subjects of the 16 chapters. They are as follows: Principles; Sands and their Preparation; Iron-Melting and Testing; Cupolas, Blast, and Ladles; The Shops, and their Equipment; Molding-boxes and Tools; Shrinkage, Curving, Fractures; Faults; Principles of Green Sand Molding; Examples of Green Sand Molding; Dry Sand Molding; Cores; Loam Work; The Elements of Machine Molding; Examples of Molding Machines; Machine-molded Gears; Miscellaneous Economics; Weights of Castings.

Foundry workers will find in this new edition a wealth of material quite up-to-date and in keeping with the present stage of iron founding.

Electrical Practice in Collieries.—By Daniel Burns, M. Inst. M.E., Professor of Mining and Geology, Royal Technical College, Glasgow. Published by Chas. Griffin & Company, Limited, London. 353 pages; 207 illustrations; size, 5 x 7 ins.; cloth. Price, $2.00 net.

In this work the three previous editions have been carefully revised and brought abreast with the latest developments of the industry, as well as the alterations of the laws of Great Britain pertaining thereto. Its publication is justified by the increasing of electric power in mines, particularly in the improvements with respect to coal-working machinery.

The book as a manual of information will be found useful, particularly in the author's native country, by colliery managers, under-managers, and students going up for certificates as such. The purely scientific aspects of the subject are ignored with the exception of a portion of the opening chapter, which has to do with elementary details of electric currents and units of measurement. The chapters following discuss the dynamo, the electric motor, and the applications of electricity to lighting, pumping, haulage and coal-cutting, while the closing chapter of over 50 pages deals with miscellaneous electrically-operated appliances of service in mining operations. Several chapters are concluded by arithmetical examples for the benefit of those students who may peruse the volume.

As a work generally descriptive of the application of electrical power with a minimum of technical discussion this book will be found of considerable assistance to those for whom it was especially written.

Elementary Principles of Illumination and Artificial Lighting.—By Arthur Blok, published by Scott, Greenwood and Son, London, Eng. Illustrated; size, 5 x 7 ins.; cloth. Price, $2. (Reviewed by H. W. Price, Associate Professor of Electrical Engineering, University of Toronto.)

For a small book, the treatment given principles of illumination and lighting is really good. The author has not only explained how to attack many practical problems, but has presented here and there actual cases with the solution completely carried out as he would advise.

Chapters I. and II. cover general principles, selective radiation, effect of light color on color of body illuminated, color matching, etc. The meaning of and methods of using in calculations the units of light and intensity are well explained. Only flame standards of candle power are mentioned in detail. One wonders why electric incandescent secondary standards and their proper use are given seven lines only, when a thousand of them are in use in industrial photometry for every flame standard in service.

Chapter III. gives illustrated description of various commercial photometers, followed by four pages of excellent advice on the use of them in field work. Chapters IV., V., VI., devote 60 pages to all sorts of calculations on lighting and illumination. Explanation of each method is followed by examples from practice completely solved as the authors would recommend. Numerous diagrams and tables are arranged to assist the reader. Chapter VII. is devoted to typical distribution curves from gas and electric light sources, and the science of converting these as efficiently as possible to any other form desired by reflectors, globes and shades. Chapters VIII. and IX. are specially upon problems of indoor and outdoor illumination. Examples are included showing how to value actual requirements of practice. The last chapter deals specially with the properties of illuminants.

The book is pocket size, yet it has a complete contents, list of tables, five useful appendices, a list of symbols employed, a reference list of 20 equations used, a cross index,

and a list of other authors referred to in the text. Our opinion is that this small book is most useful to any requiring assistance in work on illumination.

Motorcycles, Side Cars and Cycle Cars.—By Victor W. Page, M.E. Published by the Norman W. Henley Publishing Company, 132 Nassau Street, New York. 550 pages; 339 illustrations; size, 5 x 7 ins.; cloth. Price, $1.50.

This book is a comprehensive, non-technical treatise, defining all forms of the lighter self-propelled vehicles, principles of operation, construction and practical operation of components in the leading machines. It contains detailed advice on management, maintenance, and repair of all representative types.

Undoubtedly the growth of the motorcycle industry has created a field for a book of this nature. The motorcyclist has heretofore been obliged to acquire his knowledge by much research and reading because the books on motorcycling have been in the nature of elementary pamphlets rather than works of any pretensions. He will find in the work at present under discussion some very useful material, easily understood and up-to-date.

Memorials of Henry Forbes Julian.—By Hester Julian. Published by Chas. Griffin & Company, Limited, London. 310 pages; illustrated; size, 6 x 9 in.; cloth. Price, $1.50 net.

These memorials of Henry Forbes Julian, a member of the Institution of Mining and Metallurgy of Great Britain, joint author of "Cyaniding Coal and Silver Ores," and who perished in the Titanic disaster of April, 1912, have been written and edited by his wife, the author of a number of widely-known biographical works. In the course of his profession as a mining engineer the subject of these memorials was called upon to travel in many countries, and his prominence in the metallurgical industry resulted in a widespread reputation and recognition. He was one of the pioneers of metallurgical work in South Africa, as well as having taken an active part in the development of mining in Germany, Mexico and the United States. The text affords ample indications of his scientific acquirements, his patient industry and adaptability to varied circumstances.

Clean Water and How to Get It.—By Allen Hazen, consulting engineer, New York. Published by John Wiley & Sons, Inc., New York; Canadian Selling agents, Renouf Publishing Company, Montreal. 196 pages; illustrated; size, 5 x 7 ins.; cloth. Price, $1.50, postpaid.

This is the second edition of Mr. Hazen's book dealing with matters of general policy, pressure, fire service, sale of water, and the financial management of waterworks. The volume describes a number of plants and their methods of operation, to illustrate the principles involved. The second edition contains chapters upon the disinfection of water and the "red water" trouble, as well as a general bringing up to date the treatment of the subject in general. The problems of water supply from large and small lakes, from rivers, and of ground water are concisely dealt with in separate chapters. Chap. 6 is devoted to a discussion of the action of water on iron pipes and the effect thereof upon the quality of the supply, together with an outline of the recognized methods for the elimination of trouble in connection with the same.

The development of water purification in America is historically dealt with in a very concise yet comprehensive chapter. The questions of tastes, odors, coagulation and filters are clearly explained. Chap. 9 deals to some length with the nature of purification methods, classifying the processes into mechanical separation, coagulation, chemical purification, disinfecting processes, biological processes, aeration, and boiling. Chap. 10 deals entirely with disinfection, Chap. 11 with the application of the methods of water purification, arranged according to the matters to be removed by the treatment; Chap. 12 with storage of filtered water; Chap. 13 on the required sizes of filters and other parts of waterworks; Chap. 14 as to the pressure under which water is to be delivered; Chap. 15 on the use of measurement of water; Chap. 16 on the financial aspects of the water supply problem; Chap. 17, the laying out and construction of works, and Chap. 18, on the financial management of publicly-owned water supply systems.

The book is very carefully indexed and will be found useful by engineers and waterworks superintendents.

A Glossary of Road Terms.—By H. Percy Boulnois, M. Inst. C.E., city engineer of Liverpool, etc. Published by St. Bride's Press, Limited, London, England. 71 pages; size, 5 x 7 ins. Price, 50 cents net.

The convenient manner in which this glossary has been prepared will receive an enthusiastic welcome from highway engineers. The author's attempt to standardize the nomenclature of road terms appeared last year in the columns of The Surveyor, London, and has resulted in a number of valuable suggestions and criticisms which the author has subsequently incorporated in his work. The glossary follows closely the road terms of the Engineering Standards Committee, the author taking this step advisedly and refraining from technical and geological terms of various rock materials in use.

Oil Fuel: Its Supply, Consumption and Application.—By Edward Butler, M.I.M.E. Published by Chas. Griffin & Company, Limited, London, Eng. 328 pages; 150 illustrations; size, 5 x 7 ins.; cloth. Price, $2.00 net.

This is a third and considerably enlarged edition, and comprises an exhaustively and systematically classified record of the development and progress made in the application of oil fuel for marine and naval purposes, locomotives, road vehicles, lighting, domestic, metallurgical, and other purposes. The relative advantages of steam, compressed air and mechanical action as an atomizing addition for liquid fuel-burners is treated carefully in thirty pages, which include the results of a number of tests. The technical composition of fuel oils, their thermodynamic properties and a history of combustion methods are each treated to some length, while the origin, production and sources of supply of liquid fuel are dealt with in an interesting and authoritative manner. The production of petroleum in the chief oil-producing countries covering a period of a number of years is also given.

The book will be found of distinct value to engineers and manufacturers who encounter various problems connected with the combustion of oil fuel.

Report of a Plan of Sewerage—City of Cincinnati.—By Harrison P. Eddy, Consulting Engineer; H. M. Waite, Chief Engineer, Department of Public Works, and H. S. Morse, Engineer-in-Charge. 730 pages; plates, maps, diagrams, and tables; size, 6 x 9 ins.; cloth.

This is one of the most complete reports on the sewerage of a city that has ever been published. The general report, of 32 pages, outlines the matter treated and the conclusions reached. The treatment of the development of the sewerage system, an account of the detailed underground survey of the existing system; a topographical survey for future plans; data on rainfall and runoff, the planning of relief sewers, of intercepting sewers and creek mains, and the

disposal and treatment of sewage are subjects that are very fully discussed. Although the greater part of it is of purely local interest, there are many theories of general application and matters of similar interest to municipal and sanitary engineers.

PUBLICATIONS RECEIVED.

Annual Report of the City Engineer of the city of Halifax, N.S., for the civic year, 1912-1913.

Labor Organization in Canada.—Third Annual Report for the year 1913, issued by the Department of Labor at Ottawa.

McGill University Calendar, 1914-1915, containing full information regarding all departments and faculties, details of courses, etc.

Proceedings of the Union of Nova Scotia Municipalities at the eighth annual convention, held at Bridgewater, N.S., on August 27th, 28th and 29th, 1913.

Monthly Bulletin of the Canadian Mining Institute.—Edited by H. Mortimer Lamb, Secretary. This bulletin represents the proceedings of the Institute for the month.

28th Semi-Annual Report of the Sewage and Water Board of New Orleans.—This mid-year report consists of brief financial statements and synopsis covering the previous six months.

Notes on Radium-Bearing Minerals.—A 26-page handbook, listed as Prospectors' Handbook No. 1, issued by the Geological Survey Branch, Department of Mines, Ottawa. Compiled by Wegatt Malcolm.

Summary Report of the Geological Survey, Department of Mines, for the calendar year 1912. A 544-page summary of the operations of the Geological Survey for 1912, including the reports of the various officials on the work accomplished by them.

Progress Reports of Experiments on Dust Prevention and Road Preservation, 1913.—Bulletin No. 105, issued by the United States Department of Agriculture, Washington, covering experiments made at Chevy Chase, Md., with supplementary reports.

Year Book, 1913.—Issued by the Swedish Chamber of Commerce in London. The contents include the first annual report of the council, transactions of the year, and various lists, statements and reports; in addition several plans, maps, and full-page illustrations.

Flumes and Fluming.—By Eugene S. Bruce, expert lumberman. Issued as Bulletin No. 87 by the United States Department of Agriculture, Washington. This bulletin discusses the use of flumes in lumbering operations and tells how to build them. Of special value to lumbermen and log-drivers.

Permissible Electric Lamps for Mines.—Written by H. H. Clark, and issued, as Technical Paper No. 75, by the Bureau of Mines, Department of Mines, Washington. This paper deals with safety as a feature of miners' electric lamps, permissible tests, and specifications suggested by the Bureau of Mines for portable electric lamps.

Serpentine and Associated Rocks of Southern Quebec.—Compiled by John A. Dresser. A preliminary report, dealing, primarily, with the economic resources of Southern Quebec, with some attention given also to the petrography and structural geology of the district. Issued as Memoir No. 22 by the Geological Survey Branch, Department of Mines, Ottawa.

Precise Levelling.—By F. B. Reid, D.L.S., and issued by the Dominion Observatory, Department of the Interior, Ottawa. This publication is a continuation of two that have already been issued—Appendix No. 5 to the Chief Astronomer's report for 1910, and the 1913 publication on precise levelling. The present publication is arranged in the same general form, with the results of the levelling set forth in three tables.

Ohio State Board of Health—27th Annual Report, 1912.—Voluminous report, comprising 880 pages. Size, 6 x 9 ins.; bound in cloth. It contains the minutes of board meetings and complete discussions of the subjects taken up. Reports on proposed new water supplies and purification plants for various cities are included. Another section is devoted to reports upon communicable diseases, and another to hygienic laboratories.

Brass-Furnace Practice in the United States.—Compiled by H. W. Gillett, and issued as Bulletin No. 73 by the Bureau of Mines, Department of the Interior, Washington. The bulletin deals with the object and results of an extensive investigation conducted to ascertain the melting and fuel losses on present brass-melting losses, and to indicate, as far as possible, methods by which such losses might be reduced.

Portions of Portland Canal and Skeena Mining Divisions, Skeena River, B.C.—By R. G. McConnell. Memoir No. 32, issued by the Geological Survey Branch, Department of Mines, Ottawa. This memoir includes reports on four neighboring areas, all portions of the Skeena mining district. The main report deals with Portland Canal mining division; the others describe the results of preliminary work in the Salmon River valley, portions of Nass valley, and on observatory inlet.

Tests of Bond between Concrete and Steel.—Compiled by Duff A. Adams, and issued as Bulletin No. 71 by the Engineering Experimental Station, University of Illinois. The tests reported in this bulletin were made in the Laboratory of Applied Mechanics, and formed a part of the investigations of reinforced concrete and other structural materials which were conducted by the Experimental Station. The tests cover the experiments which were designed with special reference to a study of bond between concrete and steel during the period of 1909-1912.

The Tractive Resistance of a 28-Ton Electric Car.—By Harold H. Dunn, and issued as Bulletin No. 74 by the Engineering Experimental Station, University of Illinois. The first part of the bulletin describes the purpose, methods and final results of tests conducted by the Engineering Department to determine the resistance offered to the motion of a 28-ton electric car running on a straight, level track, in still air at uniform speed; and to asertain the relation existing between the resistance and the speed of the car. In the three appendices details are given concerning the apparatus, the methods of calculation, the test data, and the intermediate results.

CATALOGUES RECEIVED.

Merritt Sewage Disposal Apparatus.—A 16-page, illustrated booklet descriptive of the various features of Merritt sewage apparatus. Issued by the Merritt Hydraulics Company, Philadelphia, Pa.

G-E Flow Meters for Measuring Steam, Water, and Air.—Bulletin No. 46501, containing 52 pages descriptive of flow meters manufactured by the Canadian General Electric Company, Limited, of Toronto.

Electric Cable-making Machinery.—A fine, cloth-bound, 84-page catalog descriptive of electric cable-making machinery and accessories. Issued by W. S. Glover & Company, Limited, Manchester, Eng.

Lighting of Business Streets.—A small folder illustrating the adaptability of G. E. ornamental luminous arc lamps for the attractive lighting of business streets. Issued by the Canadian General Electric Company, Toronto.

Small Motors.—A well-written 20-page booklet issued by the Westinghouse Electric and Manufacturing Company, East Pittsburg, Pa., descriptive of the construction, application, and utility of electric ventilating outfits.

Heavy-Duty Corliss Engines.—Bulletin No. 1529, 20 pages, containing a brief description of the more important features of the Corliss engine designed for heavy duty. Issued by Canadian Allis-Chalmers, Limited, Toronto.

Priestman Sewage Pumping Equipment. — A 16-page booklet issued by the Merritt Hydraulics Company, Philadelphia, consisting of a complete description of the Priestman method of sewage pumping, its advantage, cost of operation,, etc.

Heat-Treating Furnaces.—A handsomely-illustrated and well-designed 40-page booklet issued by Tate, Jones & Company, Inc., Pittsburg, Pa. This booklet is descriptive of heat-treating furnaces for annealing, hardening and tempering of steel, and all heat-treating operations.

Steel Chain Belt.—Catalogue No. 54, illustrated, 32 pages, descriptive of Chabelco chain belt, manufactured by Chain Belt Company, Milwaukee, Wis. A few pages are devoted to chilled steel sprocket wheels and the application of the two to conveyer systems, paving-mixers, etc.

Tiffin Motor Trucks.—An attractive 24-page booklet issued by the Tiffin Wagon Company, Tiffin, Ohio. This booklet is fully illustrated with fine half-tones, and gives a very complete and comprehensive description of the design, construction, and utility of Tiffin motor trucks.

Recent Developments in Machine Stoking.—A 40-page, illustrated booklet issued by Ed. Bennis & Company, Limited, London, Eng. This booklet gives a complete description of modern machine stoking by the Bennis method. The text is freely illustrated with interesting photographs.

Flushtank Siphons and Water Regulators.—A 16-page, 6 x 9-in. booklet, by Merritt Hydraulics Company, Philadelphia, dealing with water flushing and control, and containing details of construction and operation of the Morse and Merritt flush-tanks, automatic and semi-automatic.

Bermudez Road Asphalt.—A 16-page booklet descriptive of some roads made from Bermudez asphalt and the wide adaptability of the latter. Many illustrations are given of some of the 12,000,000 sq. yds. of these roads in the United States. Specifications for bituminous road-binder are included. Published by the Barber Asphalt Paving Company, Philadelphia.

Gurley Scientific Instruments.—1914 Catalog, 6 x 9 ins., of W. & L. E. Gurley, Troy, N.Y., for civil, hydraulic and mining engineers' and land surveyors' instruments, including transits, levels, compasses, current meters, and all supplies for field and engineering office work. The catalog, which comprises 224 pages, is very carefully and handsomely illustrated, many of the descriptions of instruments being accompanied by full-page plates.

The Exhaust Steam-Heating Encyclopedia.—The Harrison Safety Boiler Works, New York, have issued their new 207-page edition of the Exhaust Steam-Heating Encyclopedia. This unique and beautifully-designed volume contains a complete compilation of facts and statistics concerning the improved Cochrane Steam Stack and Cut-out Valve Heater and Receiver, and its application in connection with commercial systems of exhaust steam and hot water heating. In addition, there is much other information and tables useful to heating and ventilating engineers and contractors. Canadian Allis-Chalmers are the Canadian agents.

Coast to Coast

Deseronto, Ont.—A flow of natural gas has been struck at Deseronto at a depth of 60 feet; and it is stated gives promise of heavy pressure.

Regina, Sask.—It is now expected that the street railway deficit at Regina will amount this year to only half of the estimated amount, which was $100,000.

Ottawa, Ont.—On July 20, the government steamer "Minto" sailed for Hudson Strait and Hudson Bay, to install 12 lighthouses for the protection of navigation.

Owen Sound, Ont.—As an endeavor to solve its paving problem, the council of Owen Sound has authorized the construction of a block of tarred road, as an experiment; and if this proves satisfactory, more of this road will be built.

Leamington, Ont.—It is expected that before fall, the harbor at Leamington, planned by the Canadian Government, will be ready for the use of vessels drawing not more than 26 feet. Soundings are now being made by engineers; and a breakwater will be built 300 feet out in the lake west of the present dock, which will provide a commodious and safe haven during bad weather.

St. Catharines, Ont.—In addition to the question of a water supply which is now being confronted by the town of St. Catharines, there is the question of the effect of the raising of the river level upon the sewerage system of the town. An endeavor is being made at present to solve both problems and to reach an agreement with the Department of Railways and Canals for the defraying of new expenditures that will be involved.

Sault Ste. Marie, Ont.—Such progress has been made in connection with the construction of the third lock at Sault Ste. Marie that it is expected by lock officials that it will be in use by September 1. Water has been turned into the approach at both ends; and only minor touches remain to be given to the entrance channels. The depth of the new lock will be 25 feet. A year later, it is planned to have a new fourth lock ready for traffic.

Montreal, Que.—Due to the fact that more small buildings are being erected and a correspondingly smaller number of large structures are being undertaken this year in Montreal, figures obtained from the office of the city building inspector show that for 1914, from January to June 30, the estimated value of new buildings was $8,521,910; while for the same period of 1913 the value of buildings erected was $9,942,286, or in other words a decrease for the current year of $1,400,000.

Weyburn, Sask.—The laying of steel on the new Weyburn-Lethbridge branch of the C.P.R. has been completed as far as the Alberta boundary line. This work has progressed steadily all summer at the rate of 3 miles per day, leaving only some 80 miles of its 410 miles in length to be completed. A passenger service is already being run from Weyburn to Shaunavon, which it is expected to extend to Covenlock on September 1, this latter point being practically situated on the boundary line between Saskatchewan and Alberta. In addition to the construction work on the Weyburn-Lethbridge line, the C.P.R. is also double-tracking the main line between Regina and Broadview. This work will be completed by September 1, giving a double track run practically all the way across Saskatchewan.

Montreal, Que.—The plans which are to be prepared, and have almost been completed by the architects of the Mont-

real Harbor Board, provide for a new extension to the No. 1 elevator which will be an almost exact duplicate of the addition which was completed last winter and put into operation this spring. The original elevator had a million bushels capacity, its first extension increasing this by one and a half millions, and the new extension to add a similar amount, so that the two additions will be three times the capacity of the original elevator. This new extension will cost about $750,000, and will be completed for use, it is hoped, by next September. Little beside the elevator itself will be required in the construction. It will be of the same type as the extension at the east side of the original No. 1, with huge concrete tanks to hold the grain, while the machinery in the original elevator will be sufficient to handle the grain in the whole series of bins. When this addition is completed, the Montreal Harbor Board will directly own no less than 7,000,000 bushels of elevator capacity, which will give the Montreal port an elevator equipment of well over 9,000,000 bushels, including the Harbor Commission's 7,000,000, and the Grand Trunk elevators with a capacity of 2,160,000 bushels.

Victoria, B.C.—The first section of tunnel in connection with the northwest sewer construction at Victoria has been completed. The south tunnel from No. 1 shaft, near the outfall, was pierced to meet the drift in from the open cut at McLoughlin point, the connection being made without the slightest difficulty. It will be some time, however, before the tunnel northwards under Smith Street hill will meet the tunnel work being commenced at the outfall point. Preparations are being made for driving tunnel Y, the intention being to drift in from an opening at Sea terrace as well as from the ends. Work in the open trench is also in progress at Hereward road. At the Sunnyside tunnel, where the engineers are working in from Selkirk water, about 270 feet have been completed. This tunnel will be 1,800 feet long. It is the intention to have as much of the open excavation done as possible before the rains of winter. Sewer work is also in progress in the King's road ravine, and at Oxford Street. At the latter place, the collapse of the brick surface drain proved an expensive item; but the worst of the work has been repaired. It is proposed to insert steel ties at each side of the brick work, and brace the sewer, filling in with concrete, in place of the bricks, the base where further danger threatens. It is believed that by that means it will be possible to save a considerable amount of money, and also to secure a drain which will last the lifetime of the paving.

PERSONAL.

A. M. NANTON, who succeeded Sir William Whyte on the directorate of the Canadian Pacific Railway has been elected to the vice-presidency held by Sir William on the Winnipeg Electric Railway Board.

T. R. PERKINS, assistant manager of Toronto branch of the Pedlar People, Limited, has been appointed Western manager, beginning August 1st. He will make Winnipeg his headquarters.

THOS. TURNBULL has been appointed assistant chief engineer of the Canadian Northern Railway, with headquarters in Winnipeg. For the past four years Mr. Turnbull was with the C.P.R. in the West, and with the Hudson Bay Railway, previous to which he was connected with the C.N.R. in Ontario.

A. F. HATCH, formerly president of the Canada Steel Good Company, of Hamilton, Ont., has been appointed general manager and treasurer of the Hamilton branch of the Steel Goods Company, of New Britain, Conn., the latter company having absorbed the former. Operations will be commenced without delay on the erection in Hamilton of an extensive new plant.

ARCH. CURRIE, C.E., city engineer of Ottawa, has tendered his resignation owing to ill-health. Mr. Currie assumed his duties in July, 1913, going to Ottawa from Westmount, Que., where he had been city engineer for two years. Previous to that Mr. Currie had been engaged in municipal work in Great Britain, and in railway work for 12 years in China and 10 years in South Africa. In January last Mr. Currie suffered a severe illness, and since that time, despite his many efforts to attend to civic duties, he has not succeeded in regaining his health.

OBITUARY.

The death occurred on July 19th of Mr. W. N. Allan, a third-year student in mining engineering, University of Toronto, at an age of 26. Mr. Allan was at the time resident in Oakville, Ont., being in the employ of the Ontario Public Roads and Highways Commission, making a survey of the Lake Shore Road between Toronto and Hamilton. Upon noticing a canoe overturn, throwing its occupants into the lake, Mr. Allan swam to their rescue, but death, due to heart failure, intervened. High tribute is being paid to his heroic action, and his untimely death has occasioned much sorrow among his class mates and many others who knew him. Deceased was a native of British Columbia.

COMING MEETINGS.

UNION OF CANADIAN MUNICIPALITIES.—Annual Convention to be held in Sherbrooke, Que., August 3rd, 4th and 5th, 1914. Hon. Secretary, W. D Lighthall, Westmount, Que. Assistant-Secretary, G. S. Wilson, 402 Coristine Building, Montreal.

WESTERN CANADA IRRIGATION ASSOCIATION.—Eighth Annual Meeting to be held at Penticton, B.C., on August 17, 18 and 19. Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

AMERICAN PEAT SOCIETY.—Eight Annual Meeting will be held in Duluth, Minn., on August 20th, 21st and 22nd, 1914. Secretary-Treasurer, Julius Bordollo, 17 Battery Place, New York, N.Y.

CANADIAN FORESTRY ASSOCIATION.—Annual Convention to be held in Halifax, N.S., September 1st to 4th, 1914. Secretary, James Lawler, Journal Building, Ottawa.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown, Indianapolis, Ind., Secretary.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.—11th Annual Convention; 5th American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau St., New York, N.Y.

Volume 27. Toronto, August 6, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

KANANASKIS FALLS HYDRO-ELECTRIC DEVELOPMENT

WATER POWER ON THE BOW RIVER—CALGARY POWER COMPANY'S NEW PLANT AND EXTENSIONS TO THE HORSESHOE FALLS DEVELOPMENT — STREAM FLUCTUATION AND STORAGE POSSIBILITIES.

THE Calgary Power Company Limited, of Montreal, has recently practically completed the construction of a new hydro-electric power plant at Kananaskis Falls, on the Bow River, in Alberta, about 50 miles west of Calgary. This plant adds materially to the power previously developed by the company at Horseshoe Falls, two miles distant, and built several years ago.

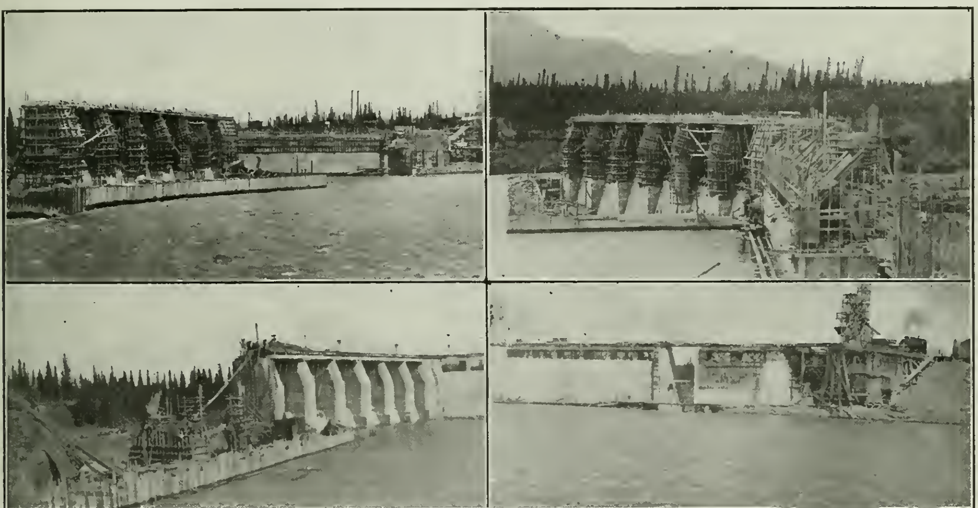


Fig. 1.—Kananaskis Dam, Showing Sluices and Spillway During Construction.

The Bow River.—The Bow River rises in the Rocky Mountains and drains an area of 3,138 square miles, 1,710 of which are above Kananaskis Falls and wholly in the mountain region. It is a typical mountain stream, rising at an altitude of some 6,500 ft. This slope is unusually steep and several falls occur. Its flow, like that of other mountain streams, is subject to sudden variations and is greatly affected by the temperature. During the hot summer months the melting of the snow in the mountains develops floods, while in the winter the cold reduces the flow to a very small proportion. There is, accordingly, a wide variation between high and low water, as evidenced by levels taken by the Canadian Pacific Railway at their bridges over Bow and Kananaskis Rivers, in the immediate vicinity of the development to be described. A flow as high as 45,000 cu. ft. per sec. has occurred at Horseshoe Falls, while a winter discharge of less than 500 cu. ft. per sec. has been recorded at the same place. The section of the river suitable for power development is some 30 miles in length and is well within economic transmission distance of Calgary. The river and the storage possibilities connected therewith, necessitated by the great fluctuation in the discharge, have occasioned very thorough investigation on the part of the water power branch of the Department of the Interior. A study of the power and storage possibilities of the river and its tributaries included the acquirement of copious information respecting run-off, rainfall and stream gauging. Mr. C. H. Mitchell, C.E., of Toronto, acted as consulting engineer to the government in connection with this work.

It should be stated that the direction of flow of the river is southeast from the mountains as far as the foot hills and thence east as far as Calgary. It then flows south and east to its confluence with the Belly River. Its many tributaries, most of them small, include the Kana-

naskis River, which runs into it at a point 53 miles west of Calgary.

Before entering upon a description of the Kananaskis Falls development, the attention of our readers should be called to the reference in *The Canadian Engineer* of June 4th, 1914, to the proposed hydro-electric plant of the Dominion Government at Banff, Alta. The storage possibilities of Lake Minnewanka were outlined therein. During the winter of 1912 the Calgary Power Company entered into an agreement with the Department of the Interior whereby the former was given the right to create a storage at this point. This involved the construction of a dam in Devil's Canyon, the outlet of the lake. The dam is a solid concrete structure about 100 ft. in length

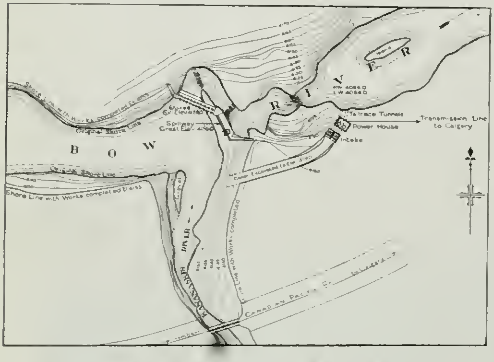


Fig. 2.—General Layout of Power Development.

and 55 ft. at its highest point. It is provided with three stop-log sluiceways and a low level sluice controlled by a gate valve, as illustrated in the article previously referred to. The dam was completed in May, 1912, and storage commenced.

Kananaskis Dam.—In the same year the Calgary Power Company was given the right to develop power at Kananaskis Falls, about $2\frac{1}{2}$ miles above the then almost completed Horseshoe Falls plant. A total drop of about 40 ft. existed at that point and, by the use of a dam at the top of the falls a total head of 70 ft. is gained. Surveys of the site were carried out in considerable detail in the late fall of 1912, and designs for the plant were worked out forthwith. The layout shows a dam across the head of the falls immediately below the point at which the Kananaskis empties into the Bow, a canal

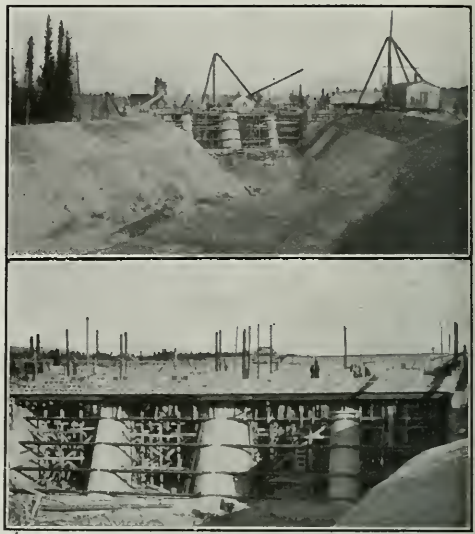


Fig. 3.—Canal and Head Gates Under Construction.

along the south side of the river, an intake, wheel pit, power house, and tailrace tunnels to deliver the water back to the river below the falls. The arrangement is illustrated in Fig. 2. The dam, construction views of which appear in Fig. 1, has a total length of over 800 ft., including wing walls. It is $57\frac{1}{2}$ ft. in extreme height and has eleven stop-log sluiceways 18 ft. in width and 14 ft. below the spillway level. It will raise the water level about 59 ft., backing it up into the Kananaskis River and necessitating the raising of a two-span bridge of the Canadian Pacific Railway on its line from Banff to Calgary

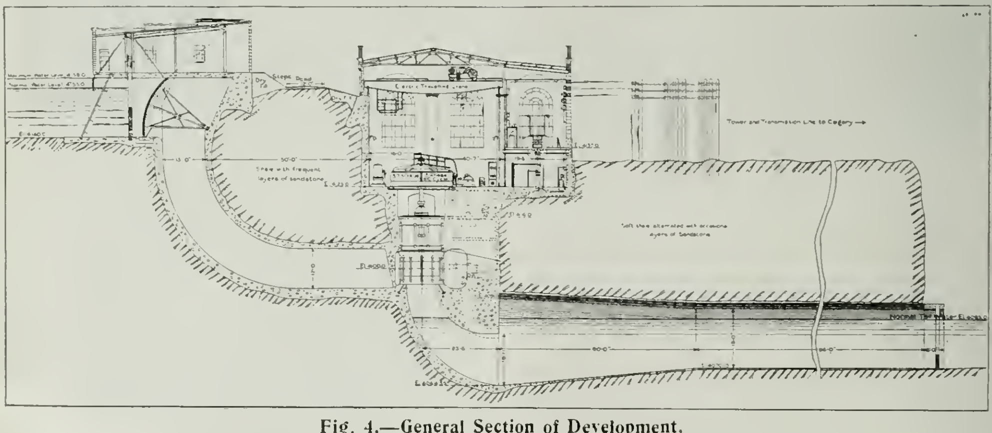


Fig. 4.—General Section of Development.

with a corresponding elevation of 4 ft. in grade. The spillway section of the dam is divided into twelve 17-ft. openings and there is in addition a low-level sluiceway controlled by a 72-in. valve. This provides for a flood discharge of over 47,000 cu. ft. per second with a 3-ft. overtop on the spillway section. There is 215 lineal ft. of free overflow in the length of the dam, high-level water being 20 ft. above the lowest stop-log opening. The wing walls, which add to the dam proper a length of 75 ft., run well into the banks at either side.

The sluiceway and stop-log sections are furnished with a deck 20 ft. in width, narrowing to 10 ft. in width over the other sections. This deck carries an electrically operated winch for the handling of stop-logs.

Owing to the earth structure below the dam being of soft shale and very seamy in spots, in order to prevent seepage the foundation was grouted. Two-inch holes were drilled about 20 in. apart on both sides of the dam and were filled with cement grout under pressure. In some places the foundation structure was so seamy as to require a very large quantity of grout before leakage ceased.

Canal and Head-works.—The canal itself has been constructed sufficiently large to carry the amount of water necessary for the maximum of the plant at low velocity. It is over 700 ft. in length and is of trapezoidal cross-section, 50 ft. wide at the bottom, 80 ft. wide at the top, with an operating depth of 15 ft. This is where it passes through gravel, as shown in Fig. 3. The canal section in rock is rectangular and approximately 50 ft. wide with a depth of 15 ft. The former portion has been lined with concrete from the forebay to the head-works. The rock portion forms a natural dam for the canal. It is in general of a seamy shale nature and alternating with occasional beds of sandstone. From the head-works two 60-ft. concrete penstocks 35 ft. wide by 13 ft. high at the head gates and 12 ft. by 12 ft. at the wheel-case, feed directly to the scroll chambers. These tunnels are located in solid rock, as are also the draft tubes, tailrace tunnels, etc.

The head gates, which are riveted steel Tainter gates, operated by electric winches in the gate house above, are equipped with stop-logs to allow for repairs to the main gates, as well as with gratings to prevent intrusion of floating debris. Fig. 3 shows them under construction. The concrete-lined pressure tubes leading from the gates develop into scroll chambers formed in concrete in which are set the turbines. The forms and method of reinforcing of these chambers are shown in Fig. 5. The draft tubes into which the turbines discharge are 30 ft. in length, varying in cross-section from 9 ft. square at the wheel pit to 16 ft. by 13 ft. at the tailrace tunnels, from which point the water flows directly into the river, as shown in Fig. 6.

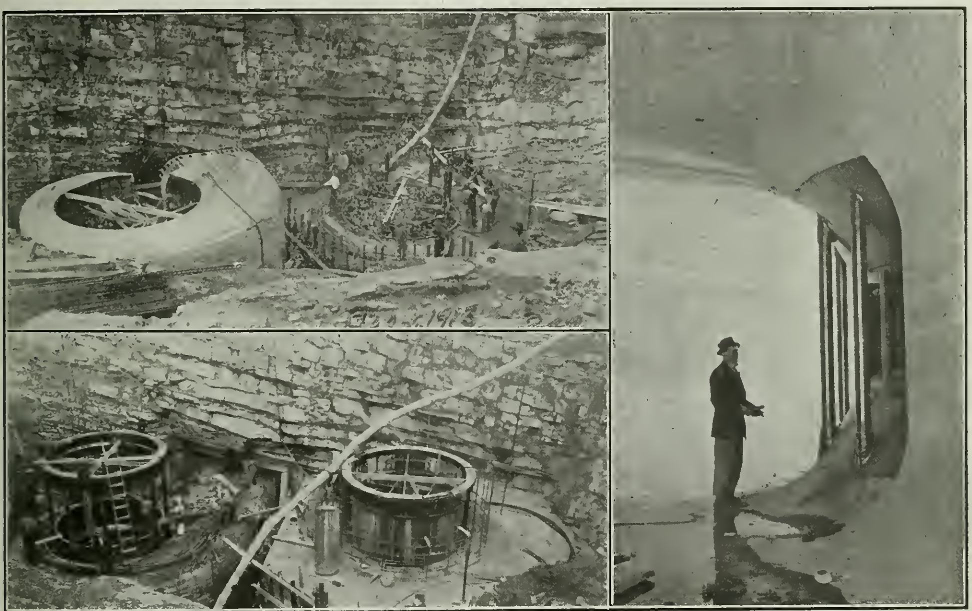


Fig. 5.—Scroll Chambers During Construction. Also Interior View of One with Forms Removed, Showing Turbine Frame in Place.

Construction Details.—The building itself is 90 ft by 60 ft., and is placed on a solid concrete foundation over rock. The lower 15 ft. of the walls are of concrete, while the structure is finished in clay brick. Sand and gravel for the concrete was obtained quite near the site. Mixing was done by steam-driven one-yard mixers in both the construction of the dam and head-works. The building of the dam itself was effected by the construction, during the winter season with low-water level, of a temporary discharge channel cut through the rock, built up with concrete and furnished with stop-log apparatus. A cofferdam was then constructed extending into the river as the current would permit. The flood season, however,

discouraged attempts to divert the whole river through the temporary runway. Accordingly a natural opening was left at the north bank until the following winter season with its decreased flow. The construction, owing to the isolated location of the development, necessitated the building of several miles of sidings as well as quarters for 600 men. A steam plant consisting of two 100-h.p. Leonard boilers supplied steam for the pumps and air compressors, as well as for the work-shop and lighting systems. As the work developed, and power requirements increased, the company's transmission line from Exshaw to Calgary was resorted to and transformers installed for the stepping down of the current from 12,000 volts to ordinary working voltage.

The gravel was obtained, as stated, close to the power works. It was moved by a Marion steam shovel with a one cubic yard dipper. From the pit it was

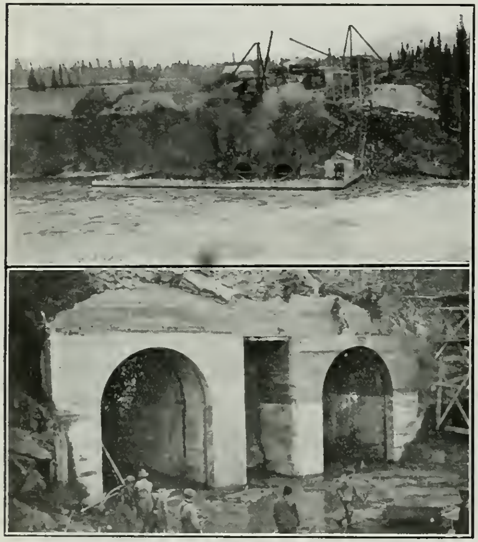


Fig. 6.—Outlet of Tailrace Tunnels.

hauled to the concreting plant in side dump cars of 6 cu. yds. capacity, drawn by Vulcan steam locomotives. The concrete mixers were equipped with hoisting towers and distribution system. They were placed about 30 ft. below the track level. Wooden hoppers with a capacity of 125 cu. yds. received the gravel from the dump cars, and discharged it through sheet metal delivery tubes with arc gates directly into the charging hoppers above the mixers. Cement, in sacks, was received at the mixers through a chute from the storage shed at the top of the bank. The hoisting and distributing towers were two in number, each equipped with Insley hoisting buckets and hoppers. One of them, 40 ft. in height, was used on the construction of the main dam, and the other, 60 ft. high, on the balance of the concreting. Side dump cars, of one cu. yd. capacity conveyed the concrete from the mixers along the deck to the towers. The plant had a capacity of 35 cu. yds. per hour.

An important feature of the construction was the excessive amount of rock excavation necessary. In the canal section a Marion steam shovel with a 1½ cu. yd. dipper loaded into two 12-yd. and eight 6-yd. Peleter side dump cars. Eight Holman compressed air drills were used in rock excavation in the canal section and in the wheel pit and tailrace tunnels. From the latter, excavation was removed by the use of hoisting engines and 5-ton stiff-leg derricks.

The construction of the tail-race tunnels required a heavy timber cofferdam to be constructed in the river.

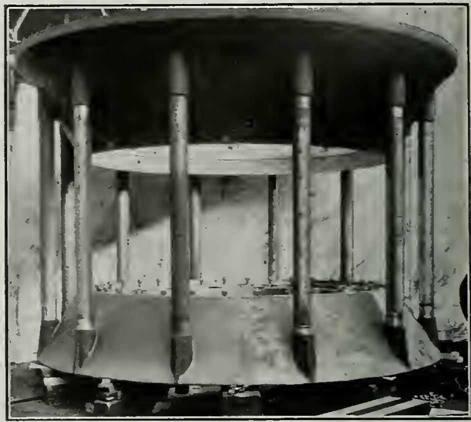


Fig. 7.—Turbine Rings and Supporting Columns. Shop View.

Excavation was then proceeded with from the river base at the same time that the penstock and wheel pit excavation was in progress.

As illustrated in Fig. 5, the forms for the scroll chambers (and the same applies to the forms for the draft tubes and tunnels) were lowered into position from the ledge of rock above.

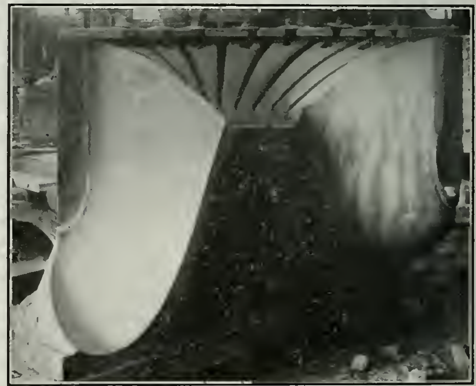


Fig. 8.—Setting Core of Cast Iron Runners for Turbine. Shop View.

The Power House.—The station contains two main turbine units and exciter turbine built by Canadian Allis-Chalmers, Limited. The main turbines are of the low-pressure vertical type set into the concrete spiral casing, described above, the local conditions of the power plant site being most suitable for such a layout. They were

constructed for 6,000 h.p. at 164 r.p.m., operating under 70 ft. head. The additional exciter turbine was built for 150 h.p. at 600 r.p.m.

In order to eliminate distortion of any castings due to the heavy shrinkage stresses in concrete work, the designers applied heavy foundation rings bolted together by means of heavy steel columns, as shown in Fig. 7. These rings were installed during the first stage of the concrete work. After all those parts, together with the concrete around it, had settled properly, the wooden forms were removed and the turbine proper was installed.

The turbines in general consist of a solid speed ring and a guide wheel with bearing. The speed ring holds the bottom and top plates, which are designed to hold the cast steel guide vanes. This guide wheel is of the outside gate rigging type. Each guide vane swivels around a heavy shaft which is cast together with it.

is placed upon a rigid cast iron spider, which is resting upon the upper foundation ring already mentioned. All bearings, as well as the spider, are adjustable.

Fig. 8 is a construction view showing the core for the runners prior to casting.

The generator turbine, as well as the exciter turbine, is regulated by means of oil pressure governors. For the generator turbine the oil system is so laid out that any of the motor-driven oil pumps can feed any of the governors alone or both at the same time. Special attention may be drawn to the fact that the oil pressure tanks are of ample design to store enough energy for both governors for the severest conditions, without having the pump working always to its full capacity. The pump is automatically cut out and put into operation by means of a specially designed unloading valve. A hydraulic hand regulation is placed near each governor actuator,

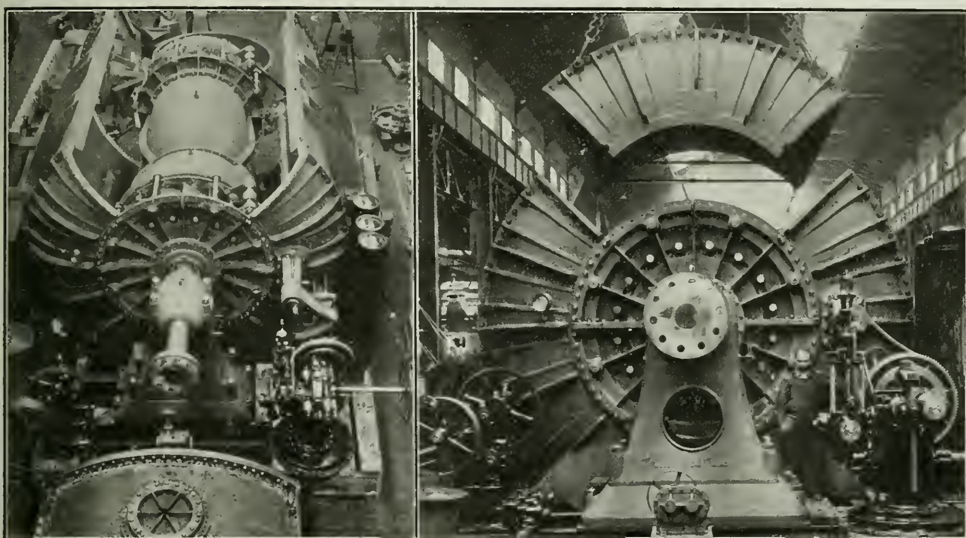


Fig. 9.—Shop Views Showing Construction of Horizontal Turbine for the Horseshoe Falls Extension.

On the upper projecting end a cast steel crank with patented breaking coupling is clamped to the shaft, and the connection to the steel regulating ring is accomplished by means of heavy steel connecting links. All bearings are bronze-bushed and adjustable. The regulating ring is placed around the heavy cast iron frame holding the water-lubricated lignum vitæ bearing for the main turbine shaft. The whole weight of this heavy ring is taken up by a set of steel balls set into oil-lubricated seats and held in place by means of a bronze cage.

The regulating ring, further, is connected to the two oil pressure cylinders by means of the shortest possible connection. These two cylinders are of heavy construction and placed diametrically opposite upon the bearing housing.

The turbine shaft is held in place by two heavily constructed guide bearings, one placed near the turbine runner, and the other immediately under the thrust bearing. This latter bearing is designed for oil lubrication, a small oil pump taking care of proper oil circulation. The thrust bearing is of the pressureless Kingsbury type, and

so as to enable the operator to regulate the machine in case of a shut-down of both oil pumps. All oil pipes for the complete oil system are made of extra heavy brass with bronze flanges.

To the turbines are connected directly two vertical, 12,000-volt, 60-cycle, 4,250-kv.a. generators of Swedish General Electric type. A motor-generator exciter and a turbo-exciter, each of 75 kw., 220 volts, 600 r.p.m., and of the same make, have been installed. The switching equipment was installed by the Canadian Westinghouse Company, and includes a vertical type, remote controlled switchboard of eleven panels, a station and service board, a lighting and a storage battery charging panel. The 12,000-volt bus-bars and electrolytic lightning arresters are situated on a gallery above the switchboard. Above them in turn the five outgoing transmission lines are run through the wall.

The installation of power house equipment was managed by a 50-ton electrically operated crane working over a 40-ft. span. The main floor of the power house has a machine shop at one end.

Capacity.—The new plant generates approximately 12,000 h.p. The station is tied with the 18,000 h.p. plant at Horseshoe Falls by two 3-phase copper-aluminium circuits. At Horseshoe Falls the voltage is stepped up to 55,000 volts for transmission to Calgary.

The Kananaskis development has cost in the neighborhood of $750,000. Mr. H. A. Moore, general manager and chief engineer of the company, has been responsible for its design as well as the entire construction. Mr. H. A. Johnston was resident engineer and had a staff of ten assistant engineers at the site. The superintendent of construction was Mr. A. W. Allen. The installation of the electrical equipment was under the supervision of Mr. E. Barnes, general superintendent.

Horseshoe Falls Plant and Extensions.—In connection with the Kananaskis Falls development, which is now known as No. 2, it is interesting to note the main points of the Horseshoe Falls plant, known as No. 1, and to mention the extensions which the Calgary Power Company has made to it. The plant consists of a dam, intake, power house, etc., all of permanent construction. The head developed is 70 ft., part of which is due to the actual fall and part to the slope of the river.

The dam is of solid concrete construction of the spillway type, measuring 140 ft. in length on the crest. Apart from the spillway, it is provided with four stop-log openings and four sluiceways controlled by Stoney sluice gates, making ample provision for discharging any flood liable to occur. In its construction the same precautions were observed to prevent leakage as have been mentioned in connection with the later development and, whatever leakage there may be is taken care of by a drainage tunnel. The intake, provided with racks and ice-clearing devices, supplies the water to four penstocks, two of which are 12 ft. in diameter and the other two 9½ ft. in diameter. The power station was designed for four units and two exciter units. At first only two units were installed, a 3,750 wh. h.p. Then, upon the storage development at Lake Minnewanka, the third unit was installed. The fourth has recently been under construction, a new 6,000 h.p. Wellman-Seaver-Morgan horizontal turbine, controlled by a Lombard governor, having been installed in connection with a 4,500 kv.a. Canadian General Electric generator, direct connected. For this increased capacity two 3,000-kw., 3-phase transformers have been placed in operation by the Canadian Westinghouse Company, together with the necessary switching apparatus. This installation has brought the Horseshoe Falls plant up to a capacity of 18,000 h.p. This, according to the 1912 report of M. C. Hendry, chief engineer, Water Power Branch, Department of the Interior, cannot be considered as continuous output owing to the wide variation of flow mentioned above. From the records available it is believed, however, that the storage at Lake Minnewanka can be very materially added to by the creation of additional storage at other points in the basin. The chief users of power from the Calgary Power Company are the city of Calgary and the Canada Cement Company, at Exshaw. The city has been, of course, the largest consumer but the extreme fluctuations in the Bow River flow, which preclude the continuous operation of the plants to their full capacity during a portion of the year, have prevented the company from guaranteeing continuous power throughout the entire year to the many users requiring it. The completion of the Kananaskis development, however, in addition to the other storages, will enable the company, it is believed, to give a guarantee of a continuous output sufficient to meet the needs of its customers.

COST OF HAULING WITH TRACTOR OUTFITS.

The following data from the Fourth Report of the Illinois Highway Commission on the cost of hauling road construction material should be of interest to contractors engaged in this class of work:—

Data on Cost of Hauling with Tractor Outfit at Hinsboro, Ill. Average Length of Haul, Three Miles.

Number of cubic yards of stone hauled by engine	2,590
Number of cubic yards of stone hauled by team	3,980
Number of days outfit was on job	120
Number of days outfit hauled (fractions counted as full)	40

Costs.

Cost to Illinois Highway Commission of engine operator (salary and expenses, straight time)	$340.00
Cost of fireman (actual time worked)	66.20
Coal, oil and supplies for outfit	181.81
Cost of maintenance of hauling outfit (one-half season)	53.00
Total	$641.01
Total cost per cubic yard for hauling	$0.247
Total cost per cubic yard to township for hauling	.096
Total cost per cubic yard to state for hauling	.151
Actual cost per cubic yard for team hauling (on same work and same length haul)	.560
Cost of hauling by engine per cubic yard mile	.082
Cost of hauling by team per cubic yard mile	.186

Detailed Costs of Engine Hauling per Cubic Yard Mile.

Operator	$0.043
Fireman	.008
Coal, oil, etc.	.024
Maintenance	.007
Total	$0.082

Data on Cost Hauling with Tractor Outfit at Mattoon, Ill. Average Length of Haul, One Mile.

Number of cubic yards hauled by engine	674
Number of cubic yards hauled by teams	2,170
Number of days outfit was on the job	22
Number of days outfit hauled (fractions counted as full)	13½

Costs.

Cost to Illinois Highway Commission for engine operator (salary and expenses, straight time)	$ 66.00
Cost of fireman (actual days worked)	27.00
Coal, oil and supplies	51.00
Maintenance of outfit	26.00
Total	$170.00
Total cost per cubic yard for hauling	$0.258
Cost per cubic yard to township for hauling	.115
Cost per cubic yard to State for hauling	.143
(Actual cost of team hauling on same work and same haul)	.435
Cost of hauling by engine per cubic yard mile	.258
Cost of hauling by teams per cubic yard mile	.435

Detailed Costs of Engine Hauling per Cubic Yard Mile.

Operator	$0.098
Fireman	.042
Coal, oil, etc.	.077
Maintenance	.041
Total	$0.258

GROUTING AND PENETRATING METHODS OF ROAD SURFACES.*

By George Green, M.Inst.C.E.,
Borough Engineer, Wolverhampton, Eng.

THE ideal road would be one suitable for general traffic, which could be made in a satisfactory manner at less expense than an ordinary tar-macadam road, at a quicker rate, and independently of weather conditions, and which would last longer than a tar-sprayed water-bound road. Such a road would be within the more limited means of local authorities who are not blessed with too much money to spend annually upon their roads.

While the author does not pretend that he has found the long-looked-for means of satisfying all these requirements, he desires to draw attention to some results which indicate how partial satisfaction may be obtained; but he more particularly hopes to be able to obtain additional information and experience on this subject which will be of advantage to those who have the somewhat thankless duty of making roads for the public with a too limited supply of funds.

It would not be out of place, and it might be helpful in considering this subject, to note a few points which the road maker is bound to consider, and which sometimes the road users and the public at large do not thoroughly appreciate.

Provision must be made to keep road surfaces, where the gradients are exceptionally steep, with sufficient foothold for horses, and in frosty and muddy weather when the surfaces are greasy, an adequate supply of grit must be at hand. At the same time, these surfaces should be kept waterproof and as free from mud and dust as possible on account of the ever-increasing motor traffic. If motor traffic was all of one kind, a well tarred, sprayed macadam would meet the case in many areas and for many miles of roads; but this traffic again is divided into various classes—e.g., heavy motors, light motors, vehicles driven by steam with broad rough tyres and heavy loads.

These various kinds of traffic require special and often expensive treatment to keep our roads in a satisfactory condition.

This paper does not deal with main roads or county roads, but more particularly with secondary roads in towns and suburbs, which, at the same time, have considerable traffic, and occasionally are liable to have to carry all sorts and conditions of vehicles and tractors.

From a maintenance point of view it has been found that one of the most difficult roads to keep in good condition is the level road, which, on account of its want of proper longitudinal fall, particularly in wet weather, absorbs a large amount of moisture. Even a waterproofed road is more or less liable, partly owing to its position, to retain moisture in its foundations or in the subsoil if the district around is of a low-lying, insufficiently drained character.

A road that has a good gradient is generally self-cleansing with every shower of rain, and has a chance of a much longer life, in addition to being more easily kept clean and in a satisfactory condition. The margins of roads where tram lines are in the centre will not be dealt with. These have caused enough anxiety, and will continue to do so, to their surveyors as long as tram lines exist, and must always require more or less special treatment. Another reason for calling particular attention to the grouting and penetrating methods is the great difficulty, which it is believed is not uncommon, experienced in obtaining the necessary supplies of tarred road materials of various kinds in the quantity and at the times when they are most urgently needed.

One frequently has the misfortune to have a long and important road undergoing reconstruction, and to be hampered and harassed with the difficulty of obtaining a sufficient quantity of these materials to continue and complete the work in anything like a reasonable time.

All these difficulties make it desirable and necessary for road makers to have more than one string to their bows, and to be able to turn to fresh sources of supply and to use various materials and methods when emergencies of this nature occur, in order to complete their road making and repairs in a reasonable time with as little inconvenience to the public as possible.

Two points that road engineers have to deal with must be emphasized: Road surfaces must not only be able to stand the suction which is the result of rapid motor traffic, with indiarubber tires, which removes the dust, grit, sand, mud and water out of the water-bound roads, and sooner or later the small and then the larger stones themselves as they become loosened by disintegration, but consideration must be given to the provision of surfaces which will withstand the vibration from heavy vehicles—horse-drawn, steam-driven, and otherwise—which, with the continual hammering of the horses' hoofs and the solid iron tires, often shake the crust of the road and also its foundations.

It is obvious that a tar-sprayed road cannot last long under all these conditions. If the traffic were uniform, the problem would be simpler, and less expensive methods might be more easily adopted. All these points have to be considered in the construction or reconstruction of any road, and, as a rule, a road crust has to be constructed on such foundations as will be able to withstand all these conditions in a thoroughly satisfactory manner.

So far, difficulties common to all road engineers have been dealt with, among which that of an adequate supply of materials is by no means the least at the present time.

It no doubt arises largely from the fact that tarred materials of one sort or another have been recognized as one of the chief and best methods of road making, and road authorities—county, urban and rural—are all, without exception, making great efforts to meet the road problem of the day, and partly also on account of the fact that tarred materials can best be laid in dry weather, as most of these new surfaces and reconstruction of roads are done in the few months in the summer which can be relied upon as most suitable for this purpose.

If anyone can discover a material which can be used as satisfactorily in wet weather as in fine, or in winter as easily as in summer, no difficulty would be found in obtaining a ready sale for it.

It seems almost superfluous to reiterate here the great advantage of tar-spraying on well-constructed macadam roads. Most engineers have found that this is of immense advantage not only in the prevention of dust and mud in main roads subject to heavy and rapid traffic, but also that it adds considerably to the life of those roads, and is a distinct advantage from a health point of view in second-rate residential roads made of macadam in which many of the poor in our towns have to live. These streets often swarm with children who use them

*Paper read at the annual meeting of the Institution of Municipal and County Engineers at Cheltenham.

as their playgrounds. The sanitary advantage of tar-spraying in these roads can hardly be over-estimated.

Leaving the difficulties of the situation generally, stress must be laid on the great importance of having proper foundations and good drainage to all roads which are to be treated with waterproof surfaces and have to bear heavy traffic. Many roads which have for years been subject to heavy traffic have been found to consist almost entirely of a number of coats of macadam laid one upon the top of the other, the whole mass resting on a clay underbed without foundation or drainage of any kind. It is impossible for roads constructed on such lines to last, and in such cases the old macadam has invariably had to be removed, and below that, to the required depth, the surplus soil excavated and removed, and in its place a foundation of 6-in. or 8-in. slag pitchers laid upon a properly formed and well-rolled bed consisting of several inches of rough, hard clinker. The advantage of this layer of clinker is to prevent the clay or underbed working through the pitchers towards the surface, and consequently causing the foundation to give way and become uneven. This usually forms an excellent drainage, and remains of lasting benefit to the newly constructed road. Upon this foundation several types of grouting or penetrating methods have been tried, the first which naturally suggested itself being that of ordinary tar. The first trial of this kind was made some five or six years ago on a road which had a natural and sufficient gradient longitudinally; there were tram lines in the centre, the whole surface on either side of the tram lines was scarified and regulated, and after that coated one stone thick with cold blast-furnace slag, carefully and sufficiently rolled in dry. After this a mixture of 40 gallons of gas-tar (not distilled), 6 cwts. of pitch and 4½ gallons of creosote oil, as the constituent parts of the grout, was poured on the surface through cans and rubbed in with squeegees; the surface was then coated with a thin layer of slag chippings and gently rolled in with a 10-ton roller, after which a second and thinner coat of the tar mixture was spread over the surface and another layer of finer grit to spread upon the top. This road surface, which is subject to a fair amount of traffic of various kinds, has lasted up to the present time with hardly any repairs except for trenches and occasional small repairs.

This class of road, provided it is constructed in dry, suitable weather, answers a very useful purpose, and, of course, is more lasting than tar-spraying and very little more costly than ordinary water-bound macadam, provided the same road material is used. Of course, a road of this kind could only be made in suitable weather, and should a period of wet weather follow the commencement of the work, completion might be delayed for a considerable time.

Experiments have been made on a similar form of road, with other forms of binding material, with varying success; in some places the earlier work has stood for a number of years, and has a very satisfactory surface, in others there have been less satisfactory results owing to the heavier nature of traffic and to a level surface. A year ago a more elaborate experiment was made with this material. The road in this case was laid in two coats; the first coat was treated similarly to the one made of slag referred to above, and after it had been thoroughly grouted and rolled in, a second coat, one stone thick, of basalt was laid upon the top, and the process repeated with the binder and chippings until the final surface was finished.

This was only done a year ago, and the length of its life cannot be estimated. The carriageway is narrow, the surface is a level one, with hardly any gradient, and the traffic of a heavy nature, mostly with iron tires, such as railway drays and vehicles of that kind. The surface today is almost as good as when it was laid down, but time alone can say how long it will last. Ordinary water-bound macadam in this road only lasts a year.

Roads grouted with Rocmac and with Glutrin have also been laid in an experimental manner, also with various results, but the latter experiments, made about twelve months ago, when the materials in both cases were mixed on boards in the form of concrete, have been much more satisfactory, and promise to make a more lasting surface, and one which affords at the same time a most excellent foothold for horses. The great advantage of these two materials is that they may be laid in wet weather even better than in fine weather, and consequently the work is not interrupted for any outside causes, as is the case with tar roads sometimes.

Beyond the fact that Rocmac and Glutrin grouted roads can be constructed in winter, they afford a much better foothold for horses. A coat of tar dressing in the summer will prevent them being dusty, and add to the length of life generally.

There may be other forms of grouted roads equally good and useful, but there is still room for further progress in this direction, and the inventor, if the method be not an expensive one, might easily make a fortune. Most engineers would be glad to have a longer period, extending through the winter, in which to continue their road work, especially as sometimes it is difficult to find sufficient employment for all their good and useful men during the winter months when work is most needed.

On July 16, in London, England, the foundation stone of the new offices of the Agent-General for the Province of British Columbia, was laid by Prince Arthur of Connaught. The building is being constructed as a further means of stimulating the general development of the province.

Chas. T. Schoen, formerly of Pittsburg, Pa., the pressed steel car inventor and manufacturer, announced recently that he is planning to establish a plant for the manufacture of pressed steel cars at Leeds, England. As yet no decision has been reached as to when the plant will be established, nor what will be the name of the projected company. But Mr. Schoen has been in communication with Betts Machine Company, of Wilmington, Del., regarding equipment for the proposed British works.

The Vancouver syndicate which purchased the Monarch Collieries at Taber, Alta., about a year ago, has decided to install a complete new plant, costing in the neighborhood of $50,000; and it is expected that the company will be ready to recommence operation in the near future. The new superintendent of the mine will be Ralph Smith, ex-Liberal member of the Dominion Parliament for Nanaimo. The company has also completed arrangements to have the spur track extended to its property from the present terminal near the Rock Springs Coal Co.'s mine.

On July 14, at Washington, in a letter from Secretary Garrison to the House Foreign Affairs Committee, it was advocated to remove the restrictions upon the importation of electric power from Canada and to retain the present limit of 15,600 cubic feet per second upon the amount of water diverted for power purposes from the Niagara River, above the falls on the American side. With the letter Mr. Garrison sent a report by Brigadier General Kingman, chief of the army engineers, declaring that the enormous commerce of the lakes probably soon would demand a ship canal between Lakes Erie and Ontario on American soil. As to the situation below the falls, Secretary Garrison said there seemed to be no reason for an express limitation upon water diverted there. He endorsed in a general way the Smith and Cline bill which, he said, "closely approached the legislation needed for the protection of Niagara River, and for the best and most economic use of its water for power development not inconsistent with navigation interests."

SPECIFICATIONS RELATING TO COMPRESSED AIR IN TUNNEL WORK.

THE construction of additional subway tunnels under the East River, New York, has required the preparation of specifications covering the new contracts. These are very comprehensive and specific and embody details of requirement suggested by the latest experiences in similar work. The requirements relating to the use of compressed air and the safety of the workers under pressure are much extended, and embody important requirements beyond those found in existing laws. These, it is understood, were specially prepared by Mr. Frederick C. Noble, division engineer, and appeared in a recent issue of the Compressed Air Magazine.

There are nearly two miles of double lines of single track tunnel excavation under compressed air, most of it shield work with cast iron lining. A large portion of the work is in sand at a maximum depth of 90 ft. below mean high water.

The first requirements are as to the sufficiency and the reliability of the mechanical equipment. The contractor must install air compression, hydraulic and electrical machinery, hoists, pumps and all other necessary apparatus of the highest grade in use for the work to be performed and having a capacity sufficient to meet not only unusual conditions but emergencies, and to afford a margin for repairs at all times. Provision must be made for storing in tanks at the boiler house enough feed water for twelve hours' supply, unless connections can be made with two independent and separately sufficient sources of supply. If electricity is used for operating compressors supplying air to the tunnel headings, the supply cables shall be in separate lines and shall each connect, if possible, with two independent and separately sufficient sources of current.

The compressors shall be capable of furnishing simultaneously to each heading an air supply sufficient in volume and pressure to enable work to be done as nearly as possible in the dry, and to afford the specified degree of ventilation. At each heading where the shield is used the air supply pressure of 45 lb. per square inch above atmospheric pressure must equal at least 10,000 cu. ft. of free air per minute as measured by piston displacement, unless both tunnels are operated from the same compressor plant, when this air supply may be reduced to 8,000 cu. ft. of free air per minute. The plant, in addition, must be capable of furnishing to all parts of the work a sufficient air supply at a pressure of 100 lb. or more if required for operating drills, grouting machinery and other pneumatic tools. The air for the compressors shall be drawn from pure outside sources and protected from fouling by lubricating oil.

The compressor revolutions shall be registered by mechanical counters, and the pressure in the air receiver shall be continuously registered. Cooling apparatus shall be provided to maintain the temperature of the air in the tunnels and caissons always at a moderate degree. All buildings for the compressor plant and in the immediate vicinity shall be as nearly as practicable fireproof and all reasonable precautions shall be taken to prevent and extinguish fires. A water line shall be extended into each heading, 200 ft. of hose, and nozzle connections shall be maintained ready for constant use at each bulkhead and no lighted candles or matches will be allowed near roof timbering in compressed air.

Medical and Sanitary Rules.—The workmen's quarters shall be well lighted, heated and adequately provided with running hot and cold water, showers, lockers and facilities for resting, for drying clothing, and for providing hot coffee. Care should be taken to keep all parts of the tunnel in a thoroughly sanitary condition and free from refuse or decaying matter. There shall always be on duty a competent physician and surgeon experienced in the treatment of the physiological effects of compressed air, and he shall care for the health of the employees and supply treatment and medicines to them whenever needed.

There shall be maintained in close proximity to the shaft at each side of the river a completely equipped hospital room with an attendant constantly in charge. Each hospital room shall include in its equipment a commodious hospital lock in two compartments, where men can be subjected to the regular working pressure if attacked by caisson disease. Such locks shall contain cots, a telephone, air gauge, and arrangements for ventilating and heating. Provision shall be made for the immediate removal and hospital treatment of any employee who may be injured or become ill. No person shall be employed in compressed air until after passing a satisfactory medical examination, and any employee absent for ten or more successive days shall be re-examined before being permitted to resume work in compressed air.

All reasonable facilities shall be afforded for the investigation of the physiological effect of compressed air, including the conduct of experiments and the collection of records in connection therewith, to be undertaken by such scientific bodies of individuals as may be designated for the purpose by the commission.

Air Chambers.—Air chambers shall be formed in the tunnels by brick, concrete or steel plate bulkheads of sufficient strength to safely resist a pressure of 15 lb. per square inch. Whenever the air pressure in the heading exceeds 22 lb. per square inch above atmospheric pressure, two air chambers shall always be in use, except when headings are being started from shafts, and the pressure in the outer one shall not exceed one-half the pressure in the heading. The distance from the heading to the nearest bulkhead shall not exceed 800 ft. during the progress of the work.

Three metal airlocks are to be firmly set and anchored in each bulkhead. These shall consist of two main locks not less than 6 ft. in diameter, heated and ventilated if required, and an emergency lock not less than 5 ft. in diameter, which shall be located as high up from the bulkhead as practicable and shall be large enough to hold an entire heading shift. When not occupied, the emergency lock shall be kept open toward the heading and ready for instant use at all times. Lock doors must operate easily. A heavy glass bull's-eye must be set in each end of each lock.

Air valves must be arranged to be controlled from inside the lock. One of the main locks shall be connected to the main air line so that it may be locked from outside. Each lock shall be provided with an air gauge and a clock. An 8½-in. air gauge shall be placed in an accessible position on the outer side of each bulkhead. A recording air gauge shall be placed on each main and shall be locked and the key kept by the engineer. A lock tender shall be on duty at all times at each lock bulkhead. A watchman shall be on duty at all times in the heading and when for any reason the work is suspended.

Safety Screen.—In each heading chamber, when the same extends beyond the river bulkhead line, there shall be provided a safety screen extending from the springing line of the tube to the track. It shall be made of substantially braced steel plates with airtight joints. It shall

be moved forward as the work progresses so as never to be more than 115 ft. in the rear of the shield. In each heading chamber, when the same extends beyond the bulkhead line, the contractor shall provide about the middle of the height of the tunnel a substantial runway, at least 3 ft. wide, leading from the shield platform to a platform at the emergency lock. The runway shall be provided with a handrail and steps or ladders at frequent intervals for access from the track level. A telephone connection shall be maintained in service from each heading and each lock to the power house and to the office of the commission's engineer corps near the shaft.

The air supply through the shaft and tunnel in each heading shall be through two pipes, each at least 10 in. in diameter, with sufficient capacity to prevent excessive drop in pressure in regular working. Each supply pipe shall be provided with a pressure-regulating valve in each air chamber and with suitable valves arranged for by-passing at a convenient point between the power house and the shaft. Special devices shall be used to deaden the noise of air supplied or exhausted.

The supply of fresh air shall be sufficient to permit work without danger or discomfort, and where work is in compressed air such supply shall be sufficient at all times and places to prevent the accumulation of carbon dioxide to a greater amount than one part in one thousand by volume. A foul-air vent pipe 6 in. in diameter shall be carried back from each heading under pressure to the ordinary atmosphere and shall be provided with a suitable regulating valve so placed as not to be readily tampered with. The compressors must be so run as to maintain at all times a change of air through the regulating valves. Special means must be provided for the rapid removal of blasting fumes.

PRIZES FOR HIGHWAY STUDY.

Awards have been made in the competition announced several months ago by the Barber Asphalt Paving Company, for papers from engineering students on the subject of asphaltic materials for highway construction. The judges of the competition, E. J. Mehren, Editor of "Engineering Record," and H. P. Gillette, Editor of "Engineering and Contracting," have made awards of prizes of $100 each to the following contestants:—

Name of Student.	College.
Frederic O. X. McLoughlin	Columbia University, New York City.
Harry Schindler	Cornell University, Brooklyn, N.Y.
B. J. Fletcher	University of Georgia, Parrott, Ga.
John W. Hill	University of Illinois, Chicago, Ill.
Robert S. Johnson	Iowa State College, Ireton, Iowa.
M. V. Holmes	University of Kansas, Kansas City, Kansas.
F. P. Gilbert	Massachusetts "Tech," Beverley, Mass.
Harold J. LaLonde	University of Michigan, Sault Ste. Marie, Mich.
Benjamin Wilk	University of Minnesota, Virginia, Minn.
Alvin C. Smith	University of Nebraska, Lyons, Neb.
O. H. Gosswein	Purdue University, St. Louis, Mo.
Alfred A. Berkowitz	Scheffield Scientific School, New Britain, Conn.
W. J. Campbell	Syracuse University, Cohoes, N.Y.

The purpose of the competition was to turn the attention of engineering students to street and road construction as a promising field of work. The company offering the prizes believes that the plan was successful in this direction.

The Mobile and Ohio Railway Company is preparing to erect a bridge across the Ohio river at Cairo at a cost of $5,000,000.

MODERN CONCRETE WORK WITHOUT FORMS.*

By James E. Payne, Assoc.M.Am.Soc.C.E.

THE art of building concrete roofs, walls and floors without forms and with fewer shores and temporary supports than has been customary is still in its infancy. In the past few years there have been a large number of roofs and floors built using for forms and reinforcement some one of the many types of ribbed metals now on the market. As the cost of wood for form work is steadily increasing and the cost of steel is decreasing, we may look for rapid developments along this line.

These ribbed metals can be divided into two general classes, those that are expanded between the ribs and those that are merely stamped, cut or bent. The expanded ribbed metal sheets which we will consider first are made in widths of from 10½ to 28 inches and in lengths up to 12 feet. The ribs are spaced from about 3 to 7 inches apart and are from ¾-inch to 1½-inch in depth. The metal used is what is known to the sheet mills as soft open heart steel and has an elastic limit before working of 30,000 to 40,000 pounds per square inch.

As these ribbed expanded metals not only act as reinforcement, but take the place of the wood forms, in a cost comparison to determine which is cheaper, ribbed expanded metal or wood forms and wire mesh, the increasing cost of lumber is a big factor. This point, coupled with a stationary or falling steel market, is one reason why ribbed expanded metal slabs have grown so popular the last few years.

Another reason is the time saved in the erection and as wood forms are not needed, several floors can be placed and poured at the same time which is usually a costly method when a complete set of wood forms are used for each of several floors.

The saving in cost by using ribbed expanded metals for roof work is still greater than for floors as the complete cost of the wood framework for a roof frequently has to be charged up to the roof alone and it cannot be distributed over several floors. Roofs are built by laying these sheets on top of the purlins, lapping about 2 inches over the supports. The sheets are held down by clips fastened over every third or fourth rib and the side ribs of the sheets are fitted one over the other and punched together, making the roof a monolithic slab. Some of these sheets are stiff enough to carry 2 inches of concrete without any vibration for spans up to 4 feet, but with spans above that, one and sometimes two temporary supports are needed. These temporary supports are built by hanging a 2 x 6 or 8 across the under side of the purlins held up by wire slings wrapped around the purlins, or wedged up on the lower flange where I-beams are used. These cross pieces held up one or two planks on edge which stiffen the metal while the concrete is being poured and while it sets. This is essentially a short span light load system and 14 feet is the maximum span, with the most economical span between 6 and 8 feet. For a span of 7 feet, No. 24 or No. 26 gauge sheets with 2 inches of concrete on top with ½-inch of cement between 15 and 20 cents per square foot, exclusive of structural steel and waterproofing. As floors are usually thicker than roofs, the cost increases proportionally.

The concrete is specified to be made of a 1:2:4 mix with stone or gravel to pass a ½-inch ring with the dust

*Abstract of a paper read before the 10th annual meeting of the American Concrete Institute.

screened out, but is usually made according to the accepted standards for concrete work in that locality. When the concrete has set enough to carry itself the wires are cut and the supports dropped, leaving the under surface of the slab ready for plaster. These temporary supports seldom cost more than 1 cent per square foot, including lumber-placing and removing. The plaster used is a cement plaster mixed about 1 to 2½ with a small amount of hair and only enough lime (not more than 5 per cent. of the volume of cement and sand) to make the cement work easily under the plasterer's trowel. For factory buildings this finish is sometimes floated, but for offices, hospitals, hotels, etc., the white coat is frequently added. The trouble of making the plaster stick to a reinforced concrete slab, usually experienced, cannot occur with ribbed expanded metals because the concrete projects through the mesh to some extent and that with the mesh formation makes an excellent key for the plaster.

Usually the first question asked by a stranger to this material is, "How do you keep the concrete from running through?" This is a natural question considering the care taken to make wood forms water-tight, but the concrete used with open mesh ribbed expanded metal is dryer than that used with wood forms. The mix is sometimes known as a quaking mixture and when dumped from a barrow tends to stay where dumped and is spread with a shovel or hoe. The material that drips through the mesh is principally water and contains very little cement. In a factory building erected this summer in Youngstown, 290 feet long, the contractors sprinkled sand on the finished cement floor below the roof, and as the roof was poured a man below shoveled up the sand and carted it out. The drip from the roof was not enough to set up the sand. It seems as if the mesh curls the mortar around itself something like the way metal lath does with plaster. In a test conducted recently to determine the amount of loss through dripping it was shown that the loss amounts to from 36 ozs. to 80 ozs. from an area of 3½ sq. ft. In percentage, this ranges from 2.6 to 4.3 per cent. loss, depending on the style of mesh between the ribs.

One of the most important advantages of using these steel sheets for combined forms and reinforcing, is that there is no waiting for the removal of forms from one floor to start the construction of another, and the delay in pouring concrete, occasioned by the time taken to place and wire the reinforcement, is saved entirely, as the concrete is poured as soon as the expanded metal forms are in place.

In the Youngstown City Hall having 6 floors—an attic and roof—all the sheets were placed and floors poured in 30 days, an average of less than 4 days to a floor. This is an important matter on penalty jobs, and also in the fall, in order to get the roof on before the snow flies. Scarcely a month goes by without the newspapers reporting a failure in reinforced concrete somewhere in this country and in practically all of these cases, the too early removal of forms is a contributing cause, if not the sole reason for the collapse. This great danger is eliminated by using materials that combine the two functions of forms and reinforcement. Another use for ribbed expanded metal is in the construction of inclined slabs. They have been built having an angle of as much as 60 per cent. from the horizontal. Formerly to build a slab like that, it was necessary to have forms on both sides. By using a dry mix and running the ribs in a horizontal direction each rib acts as a baffle to prevent the concrete from sliding down the slope. The roof over the new hotel of the Union Stock Yards and Transit Co., in Chicago, is an example of this kind.

It sometimes happens that ribbed expanded metals are used for forms only—and no attention is paid to the reinforcing value. In the roof over the Washington Theatre in Detroit, the cost of erecting and removing wood forms would have been very high as the roof was 50 or 60 feet above the pit. Ribbed expanded metal was used on top of the purlins and rod reinforcement placed above the metal. The concrete was poured and the under surface left unplastered. To plaster the underside of that roof, scaffolds would have been hung from the roof beams or built up from below at the time the roof was poured or shortly afterward. The cost of the additional reinforcement of rods was much less than the cost of the other alternative which necessitated the scaffold remaining in place several weeks or possibly months waiting for the building to reach a condition which would permit the use of the scaffold by the ornamental plasterer.

For large areas the objection has sometimes been made that these materials could not be used in connection with the gravity system of distributing concrete, because of the large amount of water needed to properly work the gravity system, and consequently the large loss through the expanded section of the mesh. For example, a roof 100 feet square needs theoretically 61.7 yards of concrete for a roof 2 inches thick. With 5 per cent. loss through the mesh, we would lose 3 yards of concrete, which at $6.50 per yard amounts to $19.50. Probably a fair average of saving secured by using the gravity system over wheelbarrows and dumpboards is 75 cents per yard, or a saving in this roof of $46. These figures show the falsity of the idea entertained by some engineers that the gravity system must be discarded if ribbed expanded metals are used as forms.

The above remarks have referred entirely to flat sheets, but the use of curved sheets is almost as large. It frequently happens that a curved or arched floor is wanted, but heretofore it has been almost prohibitive because of the excessive cost of labor in making arched or semi-circular forms. By arching these sheets and resting the ends on the lower flanges of the steel beam or on the wood sides, or bottom of the beam box, the sheets take the place of curved forms and also stiffen the concrete in the arch. These arched floors are quite popular in breweries and also other warehouses where heavy loads are liable to be applied. They are also well fitted for highway bridges.

In the Buhl Country Club at Sharon, Pa., the beams were 8 feet 8 inches apart and 24 gauge curved sheets were placed resting on the lower flanges of the I-beams. The rise of the arch was 16 inches and the concrete was poured with no temporary supports. This system is well fitted for cases where the under surface is difficult of access, as the concrete arch carries the load, the steel sheets acting only as permanent forms, and also for cases where heavy loads will be carried.

Cement non-bearing partitions are erected more cheaply by plastering cement mortar on ribbed expanded metal than by a double wall of wood forms with poured concrete between. The time lost in waiting between the time of removal of the wood forms in one place and their erection in another is saved completely as the sheets are ready to be plastered as soon as erected. Almost all competing fireproof partitions are at least 4 inches thick when finished, some as much as 6 inches. Solid plastered partitions are only 2 inches thick, which means that every lineal yard of partition erected adds a square foot to the floor space. When made of cement, these 2-inch solid partitions are as fireproof, if not more so, than any other partition in common use.

In Cleveland, at the laboratories of the Associated Metal Lath Manufacturers, a 2-inch solid partition 7 feet wide by 9 feet high was built plastered on ribbed expanded metal. On November 20, 1912, it was tested, the fire burning for two hours with a temperature averaging 1,849 degrees after the first half hour. While the partition showed some deflection toward the fire, and a number of cracks on the side away from the fire, no smoke came through and when the panel was swung open, there were but two small cracks on the side exposed to the fire. Water at Cleveland city pressure was then turned on for 2½ minutes, and while sections of plaster were washed off on the fire side, the water did not go through the partition, and it was evident that a new coat of plaster was the only thing needed to render it as fire proof as ever.

Twenty-eight gauge sheets and 2 inches of solid cement plaster has proven entirely satisfactory for interior partitions up to 12 feet high and 26-gauge sheets and 2½-inch of concrete for partitions up to 17 feet. The sheets are fastened to the floor and ceiling with a runner bar or angle which has been previously placed and lined up, the sheets being wired or clamped to the angle. 2 x 4 temporary stiffeners are wired to one side of the sheets about 4 feet apart, and are then braced back to the floor. When the opposite side is scratched in, the supports are removed and that side of the partition is plastered. The baseboard chair rail and picture mold are nailed into small blocks which are wired to the steel between the ribs at intervals and used to hold the grounds.

Some of these metals are made in such a way so that a ¾-inch electric conduit fits in between the ribs and is imbedded in the plaster. The metal is cut away as much as necessary to allow the outlet box to be placed. The average cost is between $1.25 and $1.75 per square yard complete in the populous sections of the country and we find this coat is usually less than the cost of burned clay tile partitions.

Probably the least expensive silo of all the fireproof silos now on the market can be constructed of ribbed expanded metals plastered with cement. The sheets are curved at the factory and temporarily held in place by wood uprights on one side which are removed as soon as the scratch coat hardens. By punching the ends of the ribs together so that the joint is as strong as the rib, and lapping the ends enough to develop the full strength of the mesh, the steel sheets have sufficient sectional area to resist the bursting pressure developed by the ensilage. This same method is used for small water tanks, but for larger tanks, it has been found that a better job is secured by building two walls of curved ribbed expanded metal, and pouring between with concrete. In this way, enough additional reinforcing can be introduced to take up the stress over and above those taken care of by the ribbed metal.

Floor and roof slabs are designed according to accepted engineering practice, except that they are usually considered to be simply supported at the ends and are not reinforced against negative bending stresses over the supports. A test was made on October 26, 1912, under the control of the Cleveland Building Department, on two spans of six feet each. This test was expected to prove that the accepted methods of design could be applied to slabs reinforced with sheet metal of certain patterns. Slab No. 1 was 2 inches thick and designed to carry a working load of 126 pounds. When loaded to 2½ times that, or 329 pounds per square foot, the deflection was .16 of an inch, which increased to .20, 24 hours later. Slab No. 2 was 2½ inches thick and designed for a working load of 156 pounds. Its deflection at 2½ times that was .16 of an inch, and .20, 24 hours later.

In a sheet of No. 24 gauge expanded ribbed metal, the surface of steel in contact with the concrete is about five times the surface of a round bar of equal cross-sectional area. In ordinary bar and slab construction where the bond stress on the bars seldom equal 125 pounds per square inch, the bond stress in the ribbed metal would be only 25 pounds per square inch of surface. This low bond stress is taken advantage of, by shipping painted sheets instead of plain, which prevents incidental rust during transportation. The expanded section of the street is also gripped by the concrete so practically all sides of the metal in the mesh is covered and this will reduce the bond stress still lower than 25 pounds per square inch. Numerous attempts have been made to increase the efficiency of those different metals by the spacing and height of the ribs and also changing the type of mesh between the ribs. It will readily be seen that to increase the depth of the ribs is to stiffen the sheet so the temporary supports can be spaced further apart, but when the ribs are made deeper, the centre of gravity of the steel is raised, requiring an increased thickness of the concrete slab, and the saving in the cost of temporary supports is more than offset by the additional concrete required. In conclusion, it appears that the high quality of this type of construction, with its low cost coupled with the fact that the features of design are so simple and sure, would warrant the careful consideration of all engineers and architects.

Indications seem to be that the Alberta Clay Products Company of Medicine Hat, will manufacture its brick, tile, sewer pipe, and other clay products in Saskatchewan as soon as natural gas has been found and can be the means of furnishing cheap power. This company secured the material for the manufacture of its products in Saskatchewan, though its plant is now located at Medicine Hat, where the natural gas affords cheap power for its operation.

On July 8, the new docks at Hull, England, were opened by King George. These have been constructed by the North-Eastern, Hull, and Barnsley Railway companies of Hull. This port was already third largest in the United Kingdom, and now has 11 docks with a water area of 211 acres. The quays have a length of 8,162 feet. There are 154 cranes, with a maximum lifting capacity of 100 tons, 34 coaling appliances, with a total rate of shipment of 9,980 tons an hour, and 57 warehouses having a combined storage capacity of 211,150 tons.

A report from Adelaide, South Australia, gives the following account of railway construction upon that island. Tenders for the construction of the railway from Karoonda to Peebinga were received by the South Australian government a short time ago. This is the last of the four new lines which were initiated by the government for the purpose of serving the River Murray lands in South Australia. The only other one not finished in this country is that to Wailerie, an irrigation settlement on the river, but that line is nearly completed and will be opened for traffic shortly. The two lines already working are those from Brown's Well to Parings, near the Renmark irrigation settlement, and the Railway from Alawoona to Loxton. The length of the line for which tenders have now been received will be 69 miles, and its estimated cost is $263,000. The area which will be served by the four railways when completed totals 3,113,000 acres, and the lines have been planned so that no settler in this large stretch of country will be outside a convenient distance from a railway. Good progress is also being made with the new railways authorized by Parliament to be built on Eyre's peninsula which should result in the successful cultivation of many thousands of acres. Near the capital the line to Willunga, designed to serve an old-settled district, is now being worked as far as Brighton, and it is anticipated that the whole length will be open for traffic before the end of the present year.

THE USE OF TURNED SECTIONS IN TENSION TESTS OF REINFORCING BARS.*

By E. P. Withrow and L. C. Niedner.

In conducting tests on reinforcing bars at the Municipal Testing Laboratory of St. Louis, our attention has frequently been drawn to the increase in the values of yield point and ultimate strength, caused by the removal of material in machined test specimens. Our experience has shown that in any one type of deformed bar, this increase exists as a variable quantity, the percentage increase often reaching an amount many times greater than the percentage of material contained in the deformations. This phenomenon was found to occur in "constant-section" deformed bars, and even in plain bars.

Since the standard specifications of the American Society for Testing Materials for billet-steel concrete reinforcement bars permit the use of turned test specimens of deformed bars, it is thought desirable to submit certain facts for consideration. It will be noted that the greater portion of the data has been taken from tests on a certain type of "constant-section" bar. The manufacturer's claim for the "constancy of section" of this bar has been practically substantiated by this laboratory, by comparing the elastic moduli of the bar before and after the removal of the deformations. In the computation of these moduli from their respective stress-deformation ratios, the areas of the rough bar was computed from its entire weight per foot, while in the case of the machined bar, its calipered section was used. The tests referred to cover several sizes of both round and square bars, and show an agreement well within 0.5 per cent.

In the study of the phenomenon under consideration several factors were suggested as possibly contributory. The effect of grips, the reinforcing action of large ends, and the effect of non-uniformity of steel due to segregation were among them.

Still another factor, namely, rate of application of load, could not be neglected, because working conditions in most laboratories will introduce it secondarily when reduced area specimens are tested. This factor can cause a variation of indicated yield point and ultimate strength of 1 or 2 per cent. As this amount is of the same magnitude as the percentage of steel in some types of deformations, it should not be neglected.

Many testing machines have only one motor speed with three or four speeds of pulling-heads obtained by gear shifts. One of these is usually the most convenient and is used for this purpose in testing specimens of all sizes. It has been our experience that in the case of turned specimens, if the speed of pulling-head is unchanged, the rate of application of unit stress may be increased to two or three times that found in testing the rough bar. There exists, with good lubrication, a slipping of the grips in the pulling-heads as the load increases. This is equal to the product of the wedge ratio and the approach of the jaw surfaces as they take hold of the bar, and is, in general, a function of the total load. If the bar does not slip in the grips, the rate of elongation is, therefore, the rate of separation of heads minus a function of the total load.

From the data given by Campbell in his "Structural Steel" an increase of 100 per cent. in the speed of the pulling-head could cause an increase of 1 or 2 per cent. in yield point. In this reference the term "elastic limit" has been used, although the tabulated values are yield points. As this gives the speeds of pulling-heads, it is impossible to estimate the corresponding rates of application of load. For reasons previously given, this would be different for each machine and size of bar. In Fig. 1 is shown the effect of varying rates of loading, using a ¾-in. round bar. Each point represents the average of three or four tests. The highest speed shown is below that at which inertia and error of observation could enter to any great extent.

Therefore, the average rate of application of stress has been kept constant up to the yield point in each series of tests. The differences are, therefore, somewhat smaller than those which would be reported for the same material if tested in the usual manner. Owing to the fact that this precaution was not observed in testing for the ultimate strength, the differences in ultimate strength may be too great by a small amount. This is probably not over 0.5 per cent., and is due to the change from 5,000 to 10,000 lbs. per sq. in. per minute, as may be seen from Fig. 1.

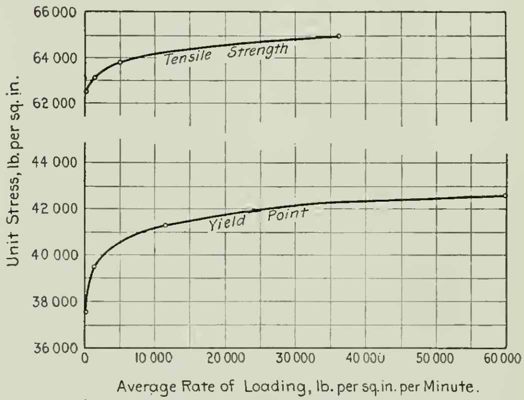


Fig. 1.—Effect of Varying Rates of Loading.

In a search for references giving comparisons of tests on machined and rolled sections, some data were found which seemed to neglect the influence of certain variables of such magnitude as would obscure the one sought for. As an example Campbell compares ¾-in. round bars with specimens made by turning ⅞-in. bars down to a ¾-in. diameter. Therefore, in the tests here described such methods were selected as would avoid the obscuring influences which destroy the value of much data of this nature.

The effect of the large ends of machined specimens could be either protection of the specimens, or reinforcing action. That the reinforcing action becomes negligible in its effect on the yield point, when the length exceeds the small diameter, has been shown by Johnson, "Materials of Construction," p. 513. As turned specimens used in the present investigation had a length about eighteen times the diameter, the only effect of large ends, if it existed, would be that of protection from the grips. The data exhibit no evidence of such protection.

To secure comparable data, several long bars were secured and from each were made various types of specimens. The different types are designated as Nos. 1, 2, 3, 4 and 5. The dimensions and method of gripping are shown in Fig. 2.

In the plain bar the yield points of types Nos. 3 and 4 agreed within about 0.5 per cent. As types Nos. 1 and 3 had received an equally severe treatment in the

* Extract of paper read before the Atlantic City convention of the American Society for Testing Materials.

grips, it was evident that the increase of the yield point of type No. 4 over type No. 1 was not due to the influence of large ends. It was seen also that type No. 3 of another bar, although badly crushed by the grips, showed a yield point 4.2 per cent. higher than that of type No. 1. It also showed an increase of 2.9 per cent. in the ultimate strength. In this bar the ultimate strength and yield point of types Nos. 1 and 2 were practically the same, although the specimens of type No. 2 were decidedly flattened by the grips.

On examination of the data from other bars, the behavior of the yield point of specimens embedded in concrete was found to agree closely with that of the same steel held in wedge grips. Owing to the impossibility of cutting many of these long specimens (type No. 5)

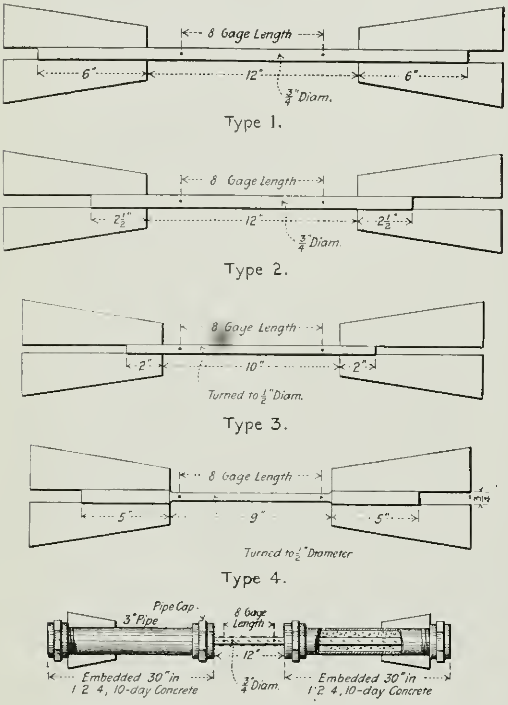


Fig. 2.—Types of Specimens.

from any one bar at our disposal, the following method of comparison was used:—

Bar No.	Percentage increase of Yield Point in concrete grips over that in wedge grips.	Number of specimens in concrete.	Number of specimens in wedge grips.
7	+ 1.5	3	7
4	— 1.1	2	4
6	— 0.5	3	6
Average	—.03		

In the investigation of the influence of grips, this method seems to effect the elimination of practically all other variables. Lack of time prevented a more extended study with type No. 5 of the effect of gripping. The ultimate strengths of specimens of type No. 5 cannot be compared with those of type No. 1, because the elongation and slip in the concrete grips after the yield point was passed made the rate of application of load uncertain. This was in evidence to such an extent that the intention of keeping it near that of type No. 1 was abandoned, and the bars were broken at a high speed. The comparison of ultimate strengths offers little interest at this point, because the soft grade of steel used showed fracture near the central portion in nearly all cases.

The appearance of a 1-in. plain, square bar, which was being examined microscopically, suggested non-uniformity of metal as one of the causes contributing to the raising of the elastic limit by machining specimens. There was a decided segregation of pearlite in the centre as well as a very marked change in the arrangement of grains in lines parallel to the axis of the bar. The macrograph of the entirely etched, longitudinal section showed the distribution and the axial arrangement of structure referred to.

The non-uniformity of steel probably offers the principal reason for the fact that most bars, plain and deformed, are known to show some increase when machined to a smaller diameter, and that this increase is known to be irregular in bars having the same kind of deformations. An examination of the photomicrographs of the specimens showed that in most cases there exists a difference in the structure of the central and marginal portions of the bars. The greatest uniformity was evident in bar No. 2. The turned sections of this bar showed the least increase of yield point and ultimate strength of any bar, about 2 per cent. and 1 per cent., respectively.

The effect of non-uniformity of structure was evidenced by bars Nos. 3 and 4. The yield points of the turned section of both of these bars showed practically the same increase—6.5 per cent. and 6.7 per cent., respectively—while the ultimate strengths are higher by 1.4 per cent. and 8.2 per cent., respectively. A marked segregation of pearlite in the centre of bar No. 4 probably explained this difference in ultimate strength.

That segregation exists over a large central portion of this bar was clearly shown. This was verified by chemical analysis on material from a 3/8-in. hole drilled axially, which analyzed 0.24 per cent. of carbon, as against 0.17 per cent. of carbon in a sample turned from the margin after the removal of mill scale and 1-32 in. of the metal. This observed difference in ultimate strength is not far from that which would be expected to accompany the difference in carbon content. Particular attention was paid to carbon because of the ease with which small variations in its distribution are detected by means of the microscope.

There has been no attempt to determine the magnitude of the effects on the physical properties caused by segregation of various elements. It has been shown, however, that large and variable differences may exist, and that these differences, probably due to non-uniformity of steel, may, even in a constant-section bar, be greater than the reduction of section due to the removal of inactive deformations.

Besides the effects of non-uniformity of chemical composition, non-uniformity of grain size and arrangement could have a marked effect on the physical properties. As the heat and mechanical treatment determine both the grain size and arrangement, and also, in a large measure, the yield point, an observed variation in one might be expected to accompany a difference in the other. Some of the photomicrographs, especially those of the longitudinal sections, show that the granular arrangement of the marginal and central portions differ greatly. This difference does not require the presence of decided segregation, as was seen in bar No. 3, where segregation was not evident, but where a more decided axial

arrangement of grains in the central portion than in its margin was found. The observation of a much greater increase in the yield point than in the ultimate strength of this bar when turned sections are used, seems to point to the reason why this increase in turned sections is rarely the same in both yield point and ultimate strength.

TRACK CONSTRUCTION AND MAINTENANCE.*

By Martin Schreiber,
Engineer, Maintenance of Way, Public Service Railway.

EVERY railway company should have approved plans and specifications for all the different elements that make up track construction as well as proper organization. Beginning with the proper rail, we find this subject has been well covered by the American Electric Railway Engineering Association, for both high T and girder rail. An important work at the last convention at Atlantic City was the final development of standard girder rail for tangent and curved track in paved streets. The Lorain Steel Company has already prepared rolls for the new 7-in. rail recommended by the association and which will be known as Section 122 No. 467. Our modern present rails all conform in a way to the new design, as to their tendency to offset the gauge line to the centre of the web, thereby causing the rail to be better balanced when under influence of wheel loads. The principles for increasing the thickness of the web and depth of groove are apparent. The new standards are only four in number and it is the writer's firm opinion that we still will see a further reduction in the type of rail used on account of the tendency to eliminate the 9-in. rail.

As far as the composition of the rail is concerned, it is now recognized that the use of open-hearth steel is the best practice. The new standard specifications of the American Electric Railway Engineering Association, which have also been ratified by the American Society for Testing Materials, provide for two schedules for carbon content. Many engineers are now strongly endorsing the higher schedule for carbon, but it seems that when welded joints are used it is better practice to use .60% to .75% carbon content to prevent binding near the joint.

The subject of proper rail joints is one of the most difficult which we have to solve. Indeed, it has been the burning question of the past, but in the writer's judgment the joint question has been eliminated to a large degree by the success which we have obtained with the modern welded joints. Besides the straight welds, very good success has been obtained with certain combination welded and riveted joints, and now we have seen a new joint coming from Europe which consists of an ordinary plate electrically welded at the edges.

Sometimes electric railway engineers follow too closely the custom of the steam roads in the matter of rail fastenings. For example, some are now advocating the screw spike, instead of the cut spike. A little consideration, however, will show that the conditions of the electric railway are entirely different from those of the steam road. There is a vast difference between a 50-ton car operating on a street railway track, which is not only spiked down but also has a solid encasement of paving, and where you have a 200-ton locomotive operating over an exposed track.

*Abstract of address presented at regular monthly meeting of the New England Street Railway Club at Boston, Mass., on May 28, 1914.

Most electric railways now recognize the economy of using treated ties and other timber. For permanent track construction the 6-in. by 8-in. by 8-ft. yellow pine tie, treated with 10 lb. creosote oil per cu. ft., seems to cover the requirements very well, and ties so treated will probably last 25 years. If you consider the pressure treatment too expensive, at least a superficial treatment of some high-grade oil should be used.

The steel tie is a good competitor of the wood tie, except that it is more expensive. We must also recognize the cushion effect of the wood tie and the advantage of shifting and aligning the rail. A number of concrete ties have been introduced, but so far experience has not demonstrated their practicability.

A few years ago many street railway companies laid their tracks with concrete foundation. Now some of them are going back to broken stone, because they find broken stone ballast lasts about as well, is just as satisfactory and a good deal cheaper than concrete. Broken stone provides excellent drainage, is easier on rolling stock, as it is less rigid than the concrete foundation, and may be installed under traffic. Besides, any shifting and aligning of tracks in the future is less expensive where broken stone has been used. Although certain kinds of soil make it necessary to provide some sort of beam support to the track through the foundation, in a large majority of cases the sub-grade which has been properly rolled and has spread upon it good sharp stone ballast that is rolled and tamped under traffic, will provide a foundation which will be satisfactory for electric railway operation.

Municipal engineers now generally recognize the wisdom in the omission of any monolith paving next to the rail, such as concrete or asphalt. If a perfectly smooth pavement is required, it is better to install wood block in preference to any manufactured block, brick or others. But, for life of service and ultimate economy, the granite block seems to stand alone.

It has not been so long ago that it was considered by even high officials in the electric railway industry that any kind of equipment was good enough for track construction. It was not uncommon to see practically no accommodation for storage yards for shipping and receiving of materials, and old and dilapidated cars were reconstructed for work cars. Track work carried out under these conditions is bound to be a business failure, and it is far better to contract the track work out.

A canvas which the writer recently made has led him to believe that very few companies know just what track work is costing them. Seldom the cost for power, interest on equipment and overhead expenses are taken into consideration, and these items should be, if you compare what the work is costing with what actual moneys a contractor would require to produce it.

Assuming that you have proper specifications and organization, along with right facilities to execute track construction, in order to get the best product for the expenditure you are making, careful inspection is a necessity. Many roads to-day are doing the work and only give the material a "once over," and are hiding behind the illusion that they are saving money. All track materials should be carefully inspected, not only the rail but joints, tie plates, track bolts, tie rods, track spikes, cement and paving materials.

From experience, the writer does not see any grounds for contention that the solid manganese is not superior to manganese inserts, if it is properly applied. Undoubtedly it does not pay to buy solid manganese at a possible 30%

increase in price over the manganese inserts, if traffic does not demand it. Besides, a great deal of solid manganese which has been cited as not altogether coming up to expectations (as we have in Chicago) was the crop of the first experiments. Now we have the pieces made up in sections, instead of the tendency toward an all-unit casting, so that if a part fails it is not always required to throw away the entire piece. In the city of Newark, at Broad and Market Streets, we have one of the busiest electric railway crossings in the country. Approximately 5,000 30-ton cars pass over this intersection every 24 hours. Previously insert crossings were good at this location for 16 to 20 months. The first solid manganese crossing which was installed stood approximately three and one-half years. I leave it to you if there is any economy in the solid manganese crossing at a cost of approximately 30% over the insert crossing. The writer has found that a very economical construction for steam road crossing is to use the old bolted type with solid manganese running and bearing rails. This crossing has an advantage of being cheap, easy to repair under operation, and still the most vulnerable point is of the best material that is known, inasmuch as the running and bearing rails in steam track are rolled manganese and here in the old type breaks generally occur.

Another important consideration in connection with special work design, which I would like to call your attention to, is the way the engineer is called on now to work on account of the varying equipment design. First, you have the city and interurban flanges; second, old and new cars with wheel bases from 4 to 6 ft., and third, steel wheels. An ideal curve design would be one which would be traversed only by cars with the same size wheel flange and the same wheel base. The proper groove of the curve is a function of the contour of the flange, length of the wheel base and the radii of curves. Theoretically every time you change the radius of a curve and the size of the wheel flange, or the length of the wheel base, the design of the groove in the curve should be altered to suit. Again, most of our special work to-day is designed for flange bearing, and it is not possible to properly design special work for two depths of flanges, still we are constantly called on to provide special work to take both city and interurban cars that have two types of flanges. It is easily seen that with special work designed for ¾-in. flange, the ⅞-in. flange cuts out the floor of your frogs, switches and mates. On the other hand, if you design the special work for ⅞-in. flange and operate ¾-in. depth flange on it, the wheel treads are pounding and destroying the points in frogs, switches and mates.

COMPARATIVE STRENGTHS OF BLASTING EXPLOSIVES.

IN the course of its investigations of blasting explosives, the U.S. Bureau of Mines made tests to determine the potential energy, the disruptive effect and the propulsive effect of some of the explosives in common use. The potential energy was measured by means of the bomb calorimeter in water. The disruptive effect was measured, using the Mettegang recorder, detonating fuse, Trauzl lead blocks and small lead blocks. The propulsive effect was measured in the Bichel pressure gauge and by means of the ballistic pendulum. The tabulated results are given herewith, together with the approximate composition of typical examples of the various explosives. The percentages figured are rated against the effect of 40% straight nitroglycerine dynamite taken at 100%.

The figures are fairly consistent with general practice, and it is believed that the classification will serve as a useful guide for comparing the practical value of explosives. It is worthy of note that the potential energy of 40% strength ammonia dynamite and of 40% strength gelatine dynamite, that is, the theoretical maximum work that these explosives can accomplish, is higher than that of 40% straight nitroglycerine dynamite, but that the disruptive and propulsive effects, which represent the useful work done as shown by actual tests, are less. Accordingly, straight nitroglycerine dynamite is more economical for general use in blasting operations if the conditions and character of the work are such as to permit its use; nevertheless, the ammonia dynamite and the gelatine dynamite are more efficient and economical for certain kinds of work that require explosives having a large propulsive effect and a comparatively small disruptive effect. For example, in blasting soft rock, 40% straight nitroglycerine dynamite, which has a very high percussive force, may be too quick in action, whereas the ammonia dynamite or the gelatine dynamite having practically the same heaving and pushing action and less percussive force will be more suitable. The tests also show that 60% strength low-freezing dynamite is not quite equivalent to the 40% straight nitroglycerine dynamite. It is worthy of note that black blasting powder has little disruptive effect, only about one-third that of granulated nitroglycerine powder.

Typical Analyses and Strengths of Common Blasting Explosives.

	Percentage Composition									Percentage Strength		
	Nitro-glycerine	Combustible Material	$NaNO_3$	ZnO $CaCO_3$ $MgCO_3$	Nitro-substitution Compounds	NH_4NO_3	Nitro-cellulose	S	C	Potential Energy	Disruptive Effect	Propulsive Effect
Dynamite:												
Straight nitroglycerine, 30%..	30	*a*17	52	1	..	..	..	..	..	93.1	84.1	96.8
Straight nitroglycerine, 40%..	40	*b*15	44	1	..	..	..	..	..	100.0	100.0	100.0
Straight nitroglycerine, 50%..	50	*b*14	35	1	..	..	..	..	..	111.0	109.2	107.4
Straight nitroglycerine, 60%..	60	*b*16	23	1	..	..	..	..	..	104.0	119.8	114.9
Low-freezing, 40%	30	*b*15	44	1	10	..	..	..	..	.....	.....	.....
Low-freezing, 60%	45	*b*16	23	1	15	..	..	..	..	60.2	93.5	91.2
Ammonia, 40%	22	*a*15	42	1	..	20	..	..	..	101.8	67.9	99.1
Gelatine, 40%	33	*a*13	52	1	..	..	1	..	..	105.7	78.4	95.8
Powder:												
Granulated nitroglycerine, 5%	5	*c*35	60	..	..	..	..	..	..	67.6	21.6	53.3
Black blasting	..	...	73	..	..	..	..	11	16	71.6	6.8	58.6

a Wood pulp, flour and sulphur.
b Wood pulp only.
c Sulphur, coal and resin.

LOGGING FLUME CONSTRUCTION.

In a bulletin, entitled "Flumes and Fluming," issued by the United States Department of Agriculture, the use of flumes in lumbering operations is discussed, with instructions concerning their construction, and some valuable data concerning volume, velocity, etc., of water to use in different sized flumes.

Of the two types in general use the V-shaped flume has proved more satisfactory, both in cost of construction and efficiency of operation, than the box or square, upright-sided flume.

The square flume is usually constructed along the general lines of the well-known mill flume or artificial conduit used to convey water from the mill pond to the mill for water-power or other purposes, but with this difference, that the uprights on the sides of the square or box timber flume are rarely braced across the top of the flume, but instead the top of the flume is left open to afford free passage for logs, wood, or lumber, and the sides are held in place by uprights fastened on the sills or crosspieces on which the bottom of the flume rests, and braced from the outside.

This is the oldest type of wooden flume in use, and is employed to some extent at the present time where economy in the use of water is not of any particular importance. However, the square flume requires more water to operate successfully with the same class of material, and, generally speaking, requires more lumber for construction than does the V-shaped flume. Furthermore, the material being handled is more apt to "jam" (especially the short material) in the square-box type. Owing to the form of its construction there are more joints in this type that are liable to open up and cause "leakage," in case the flume is allowed to stand without water running in it for any length of time, and, except where it is desired to combine in one flume the two objects of carrying a large amount of water to be used for some purpose other than fluming below and at the same time to use the flume for the transportation of lumber or timber, it is generally more advisable to use the type of flume which requires the least amount of water and the least average amount of repair. Up to the present that is the V-shaped wooden flume, but it is, perhaps, not a flight of fancy to predict that it is only a question of time when strong and light "sectional" metal flumes, semicircular in form, that can be quickly taken apart and transported from one point to another and put together and set up again, will be in common use. Metal semicircular conduits, made in sections and easily put together, have already been used in hydroelectric and irrigation projects.

The V-shaped flume is at present the type of flume most generally used in the western portion of the United States, and it has given the most general satisfaction for the transportation of manufactured lumber or timber in its different forms of logs, railroad cross-ties, cordwood, etc.

Some of the salient points in which the V-shaped flume excels are:—

(1) It can be successfully operated with a less volume of water than any other type, since, owing to the V form of construction, the water is always held confined or "compact," and, therefore, has the greatest carrying power for the amount used.

(2) There is less likelihood of jams forming, since the narrowness of the flume prevents the material from getting partially crosswise and forming a "brace," through the ends "wedging" or pressing against the sides of the flume. This is a feature especially desirable when handling short material. The narrow formation of the V-shaped flume keeps the timber running "straight," and according as the volume of water in the flume is reduced the formation of the V keeps the water confined in the smallest possible triangle down which the sides of the flume compel the material to travel.

(3) In fluming logs or round timbers the rounded portion of the log settles well down into the V. The water thus confined between the bottom of the stick and the sides of the V constantly tends to lift the log, and this keeps the stick from settling down or rubbing hard against the sides of the flume. In a square flume, on the other hand, the same amount of water could run on both sides of the log and not beneath and would so lose the tendency to "lift" through lack of proper confinement.

Thus if a log or stick of timber is large and heavy, it may sometimes nearly fill the V-shaped flume and occasionally touch both sides. But whenever this occurs the log has the pressure of the full volume of water which the flume can carry backed up behind it to force it along, and the V formation keeps the stick running "straight ahead," so that there is very little opportunity for the water to spread out or run around or get by the stick without taking it along with it. Its transportation is further aided by the uplift of the partially confined water, running around and under it, that is trying to find an outlet or relief from the pressure of the water behind, which must either aid in forcing the stick along or run over the top of the flume.

(4) In cases where it is necessary to have an unusually abrupt descent in some portions of the grade, the V-shaped flume is best adapted to serve as a "slide," or "slip," or "chute," since it is less likely to become jammed, while the material being handled is held by its own weight in proper position in the centre of the V. In a great many localities this particular feature of control of the log or stick of timber when it is "coasting" will be found very necessary in handling material from the higher mountain slopes, especially in places where it is impossible to maintain a steady and equable grade from the top to the bottom of the mountain without too great expense, and where it may be necessary to have a form of construction that will carry logs or timber safely for a long distance when the grade is so abrupt that it is impossible to maintain a sufficient volume of water in the flume to prevent the material from rubbing or sliding along on the sides and bottom. In such localities and under such conditions the V-shaped flume, when strongly constructed so as to combine both the objects of flume and chute, has been and will be found altogether the most desirable.

In the construction of flume sections angles of from 70 to 110° have been tried; but the consensus of opinion favors 90°. Construction methods are dependent upon the kind of material to be handled. The sections vary in length from 6 to 20 ft. Sometimes only one thickness of board is used, but more often two thicknesses are employed, with joints broken or staggered. The details of the box construction is largely a matter of individual opinion. The aim almost always is to keep down leakage.

A triangular section of wood, sawed to fit snugly into the bottom of the V on the inside in sometimes employed for purposes of reducing the amount of water necessary and strengthening the flume itself. The value of this measure is, however, disputed on the ground of too great cost.

Size of Flume.—The kind of material to be handled is a prime factor in determining the size of a flume. If a 30-inch V-shaped flume would satisfactorily handle the material, there would be nothing gained by going to the

extra expense of constructing a flume with a V of 48 inches. On the other hand, it is always good policy to construct a flume large enough to carry sufficient water to handle the material desired with certainty and dispatch. For railroad cross-ties, cants, poles, cordwood, etc., the 30-inch flume is usually large enough, wherever there is a sufficient volume of water available to fill the flume two-thirds full, while for the handling of logs, piling, long timbers, or "brailed" sawed lumber it is usually advisable to have the flume constructed with the sides of the V from 40 to 60 inches in height, according to the volume of water available and the size of the material to be handled. This is also a feature in flume construction in which the prospective operator can save money by not constructing his flume larger or in any more expensive form than is actually needed, since every additional inch in height means the use of more lumber in construction, and is consequently an added and unnecessary cost.

Grades.—The matter of grade in flume construction is one of great importance. Flume operators have found the question of satisfactory grade to be one of the most important features of successfully fluming material, since where there is a stretch of comparatively flat grade the supply of water may be ample to nearly fill the flume, but upon arrival at a point in the flume line where the descent is very abrupt, the accelerated speed of the water reduces its volume to a small amount in the bottom of the flume, and, consequently, results in the flumed material "rubbing" or "sliding" down the descent for a long distance on the sides of the V. Such action wears out the lining very rapidly, necessitates its being frequently renewed, and produces a dangerous condition through the liability of the material to jam and pile up, and either be thrown out of the flume or break it down as a result of the increased weight.

In general, the lowest grade that is considered satisfactory for successful operation is approximately 1 per cent., or 1 foot in 100 feet, but it is better to maintain a grade of from 2 to 5 per cent. when possible. The maximum grade that can be used runs up to a very high pitch; some flumes have been successfully operated for a short distance at a grade of 30°, but such a steep grade is very undesirable, as it is usually impossible to maintain a sufficient volume of water in the flume. The most satisfactory results in fluming will be obtained at from 2 to 10 per cent. grade, and it should be held below 15 per cent. whenever possible.

Curves.—In the location of a flume line, for obvious reasons a sharp curve is inadvisable. It throws the weight of the material and water to the outside of the curve, with a tendency toward jamming. The degree of curvature should be kept as low as practicable, and should rarely be permitted to exceed 20°. Shorter "boxes" and the closer spacing of supporting bents, arms and bracing are very necessary in sharp curves.

Feeders.—Feeders constructed at various points along the line are necessary in order to maintain the requisite amount of water on different grades.

A Glasgow, Scotland, publication announces that the select committee of the House of Lords has passed the bill promoted by the corporation of Glasgow with reference to the building of a new bridge over the Clyde, at Glasgow, between Oswald Street on the north side of the river and Commerce Street on the south. The new bridge, with the necessary alterations to provide a suitable approach to it, will cost about £300,000. The bill permitting the bridge to be built will be proceeded with, subject to certain restrictions. A delay of 1½ years has been added to the five years in the original proposal.

PROPOSED RAILWAY VIADUCT, TORONTO.

By W. H. B.

Is the proposed railway viaduct along the Toronto waterfront a mistake? In 1907 the city had an investigation and report made by Wm. Barclay Parsons, of New York, an engineer of international reputation, Chief Engineer of Subways in New York, etc., and the late Cecil B. Smith, who also was a well-qualified and experienced engineer, acting with Mr. Rust, the City Engineer, on the general question of traffic facilities along the entire front of the city.

The main feature of this report was the consideration of elimination of level crossings, particularly along the central part of the city. Two schemes of doing this were worked out and considered in all their bearings:—

Scheme 1. Elevating the tracks.

Scheme 2. Placing the streets on overhead bridges.

As to elevating the tracks, four main running tracks only were considered (the viaduct scheme as adopted), and not the great network and ramification of existing surface tracks. For operating surface tracks retained it had been proposed—not by the engineers making the report—in recognition of the great danger of running trains close to, and, therefore, obstructed by, the masonry of the viaduct, that shunting on these tracks be limited to the night hours, or that the shunting engines be preceded by a man on foot carrying a flag—a rather fatuous scheme for handling the traffic on the numerous private sidings to shops and warehouses and the harbor traffic of a city of 500,000 population.

Summarizing, the report gave for Scheme 1:—

Advantages:—

Every street would be carried through to the waterfront at its existing elevation.

Disadvantages:—

First—The raising of the station would place the tracks westerly of it at such a height as to require the abolition of the John Street bridge.

Second—The existing freight yards would have to be reconstructed.

Third—The shifting and delivery facilities on the Esplanade would have to be reduced.

Fourth—Crossings of the shifting tracks on the Esplanade would still remain.

Fifth—Greater cost.

For Scheme 2:—

Advantages:—

First—No interference with existing tracks.

Second—Delivery facilities on the Esplanade could be increased.

Third—A lower cost.

Fourth—Better appearance to persons approaching from the water.

Disadvantages:—

That some streets would be cut off before reaching the water.

Scheme 2 is elimination of level crossings; Scheme 1 is not. In fact, with the inevitable growth and further ramifications of local distributing tracks as business and consequent traffic increase the expected relief by a viaduct eliminating the four main running tracks only will be found to be largely visionary. The report strongly advocates Scheme 2, the retention of steam railway tracks on the surface and the placing of street lines on overhead bridges as the only practicable elimination of level crossings at this location.

The city report as printed is accompanied by a report on the same question made to the Toronto Board

of Trade by the late R. M. Berrian, who was a well-known Boston engineer, and by J. W. Moyes. This report advocates the viaduct as against street bridges.

For some reason not clear the viaduct scheme found popular favor, was loudly acclaimed by the daily papers without thought of technical analysis of the situation, and was adopted.

Several features not considered in either report are pertinent to this inquiry.

Traverse by street cars along the passenger landings, which, though numerous, are practically all along a short section of the waterfront, during the season of navigation at least, is an urgent requirement, and a car line will in any event be wanted along the new harbor street, outside of the railways, shown in the Waterfront Development plans (1912) of the Toronto Harbor Commissioners. Tracks for such cars would have to cross the remaining surface steam railway tracks at grade. The required protection by interlocking derails and signals at such complicated level crossings would be intricate and costly, and a great hindrance to traffic.

The bridges to carry streets over railways contemplate the clearance of 22 ft. over top of rail, specified in the Dominion Railway Act of 1904. A statement of facts will be of interest in this connection. The Railway Age Gazette of Dec. 12, 1913, gives a tabulated "Resume of City Requirements for Grade Separation Work" for various States in the United States and for Canada. Clearance requirement for overhead bridges varies from 15 ft. to 22 ft., the latter the Canadian requirement, which is the highest of all. In the city of New York, where electric traction is used exclusively for railways, within the electric zone, extending beyond the city limits, the clearance requirement is 16 ft. 6 in.

The recently renewed Milwaukee Avenue and Desplaines Avenue double viaduct in Chicago traversing a trackage width of 460 ft. and crossing main tracks of the Chicago, Milwaukee and St. Paul, the Chicago and North Western and the Pennsylvania Railways, has clearance over top of rail of only 15½ ft.

In main line crossings over the Pennsylvania and other railways in Pittsburg, with all steam locomotive traction, bridges with clearance over top of rail as low as 17 ft. 2 in. have long been in use, and the same may be said of crossings in many cities in the United States.

Rolling stock and railway conditions generally are practically identical in the United States and Canada. In fact, rolling stock, which determines clearance requirement, is constantly interchanged.

With clearance of 17 ft., or even 18 ft., over top of rail, instead of 22 ft., the Toronto problem would assume an entirely different aspect, and the only plausible argument for a viaduct instead of street bridges, even by Mr. Berrian in the Board of Trade report referred to, would disappear.

A consideration that has important bearing on this inquiry is the electrification of steam railways, within the city district at least. With electric traction control of trains, short or long, is better, and the need of brakemen on top of car less, making for material reduction of overhead clearance.

In cities such as Toronto smoke abatement is one strong reason, among others, for electrification. Careful observers claim that in the city of Chicago 47 per cent. of the city smoke is caused by railways.

Notwithstanding the recent very material improvements in economy and power of the steam locomotive, during the past ten years or less, electrification of steam railways is steadily progressing throughout the world, particularly at terminals and at other places of congested traffic. In and about London and elsewhere in England vast schemes of electrification have been already accomplished and are under way. The same may be said of almost every country in Europe. As one instance, the Giovi railway, running from Genoa, a line with heavy grades and long tunnels, has demonstrated an increase due to electric traction of 100 per cent. in capacity during the past four years. To come nearer home, and considering progress of the past year or so only, mention may be made of electrification of New York, New Haven and Hartford lines out from New York, of Pennsylvania lines in and about Philadelphia and Pittsburg, of parts of the Norfolk and Western, the Chicago, Milwaukee and St. Paul, the Atchison, Topeka and Santa Fe, the Southern Pacific and other lines. The success attending the electrification of the Butte, Anaconda and Pacific, in economy and general improvement in operating, has resulted in power contracts being placed for 440 miles of the Chicago, Milwaukee and St. Paul. The Canadian Pacific Railway has planned large electrification in British Columbia.

The advance in the past seven years, since presentation of the reports referred to, in the availability of electric energy in south-western Ontario, due mainly to the activity of the Hydro-Electric Power Commission of Ontario, has been greatly beyond expectation. It is not yet four years since this commission began transmitting electricity, Oct. 11th, 1910. It was then thought the distribution would not reach 100,000 h.p. in forty years, while now it is already 90,000 h.p., with all difficulties of the beginning period practically overcome. Electrification in such contiguous cities as Buffalo, Hamilton and Toronto will in the near future have to be seriously considered, and who will say it will not prevail throughout the district from Windsor to Toronto, if not to Montreal, with the greatest available source of hydro-electric energy in the world alongside.

This electrification feature alone merits reconsideration of the whole question of Toronto transportation facilities.

A few odd figures have been taken at random from the 1913 annual reports of the C.P.R. Company, showing accounts for additional improvements to the system have been $29,000,000; for rolling stock and machinery, $30,000,000; for construction of acquired branch lines, $9,113,050; for Ogden shops at Calgary, $2,446,035; for dividends paid up to June 30, in round figures, $15,000,000.

Particulars recently published by the C.P.R. company in connection with its policy of bridge construction, gives the following interesting figures of dimension and cost for four outstanding structures, e.g., the Lethbridge viaduct, the Outlook, the Edmonton, and the Lachine bridges. The first is 5,327 feet long and 314 feet above the water level, with a weight of steel of 25,000,000 pounds; and cost $1,500,000. It was made up of 44 through plate girders 67 feet long, 33 girders 100 feet long, and one 167-foot truss span supported on 33 steel towers. It required 645 cars to transport steel used in construction. The second bridge, across the South Saskatchewan River, is 3,004 feet in length, 140 feet above water level, and has a weight of 5,737,000 pounds of steel; and cost $900,000. It has 240-foot truss spans, supported by concrete piers, with approaches consisting of three 80-foot, seven 60-foot, and nine 45-foot plate girder spans on steel towers. The third, over the North Saskatchewan, is 2,550 feet in length; is 152 feet above the water level; has 16,204,146 pounds of steel; and cost $1,400,000. The fourth bridge—the Lachine, across the St. Lawrence—has 3,657 feet of length; is 60 feet above water level; has 28,462,931 pounds of steel; and cost $2,000,000—that is, both for converting into double track, and for the original cost of the structure, which was something like $1,500,000. It has three 80-foot, nine 120-foot, four 240-foot, two 270-foot, and two 498-foot spans; and 19 piers, 3,500,000 rivets; while 3,500 cars were required to handle the material employed in the entire structure.

SOME LARGE CYLINDRICAL VALVES FOR HIGH WATER PRESSURES.

The valves or water-gates used or projected to be used by the United States Reclamation Service under great heads at reservoir outlets are described as follows by Gen. W. L. Marshall, United States Army consulting engineer to the Secretary of the Interior, in No. 27, Vol. VI. of "Professional Memoirs" of the Corps of Engineers. They are slide gates for guard valves and automatic plug, or needle, valves for closely regulating discharges. Under great heads the slide valves are difficult to operate, and when of considerable size are not practicable under pressures due such heads, especially since roller bearings applied to them have failed in practice. The use of slide valves must then be restricted to sluice gates operated under moderate or low heads, and to guard gates for regulating valves, to be operated in still water.

The regulating valves, designed and used in the Reclamation Service, form a distinct cylindrical class wherein the cylinder is closed at top, which top projects beyond the cylindrical body and forms a hydraulic piston in direct connection with the valve. The bottom of such type is also closed by a conoidal or concave surface of revolution terminating in a point at the axis of the cylindrical body prolonged. The projection of the top surface or "bull-ring" closely fits the surface of, and moves smoothly into and out from a hood or housing, just as

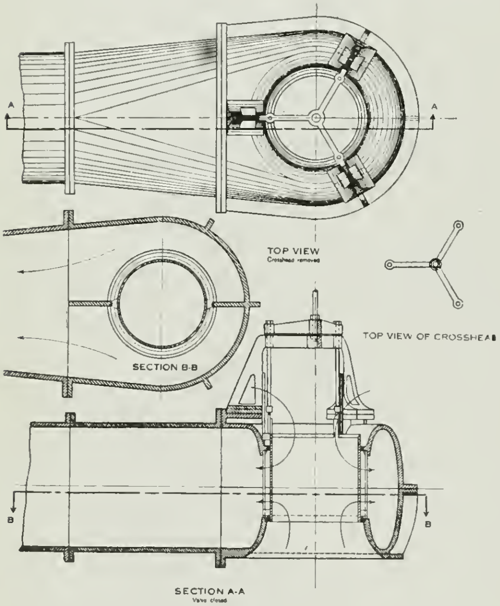


Fig. 1.

a piston of a hydraulic engine moves in its cylinder; and carries the plug or valve to and from its seat.

These automatic but controllable plug or needle valves are in many of their principal features, if not all of them, the inventions of Mr. O. H. Ensign, Chief Electrical Engineer, and of Mr. F. Teichman, Engineer in the United States Reclamation Service, and are very interesting, useful, and scientific applications of the laws of the mechanics of fluids, correct in principle and extremely ingenious. Quite a number of the Ensign valves have been in use for several years. The Teichman type has not yet been tried, but has been contracted for to be placed in the Elephant Butte Dam on the Rio Grande.

The regulating plug valves are automatic but controllable, and are used under heads up to and greater than 100 feet quite successfully. They still have some minor defects, but all such defects seem to be remediable, and doubtless will be remedied shortly.

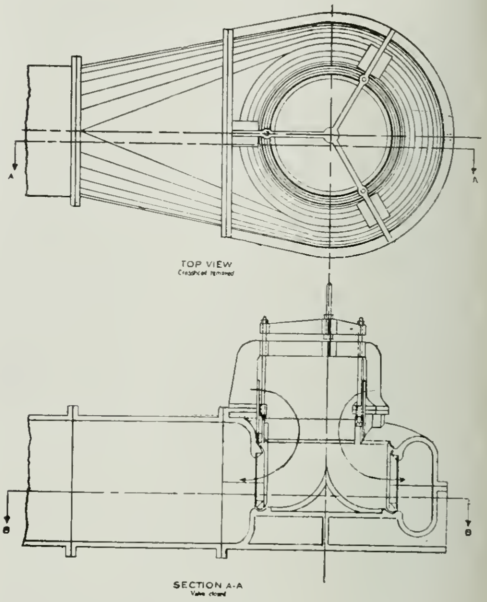


Fig. 2.

In operating these valves not only is hydrostatic pressure used and controlled, but auxiliary forces such as "suction" from artificially produced partial vacuums in the housing, and "reaction" due the change in direction of the discharge by the curved surface of the bottom of the plug. The main differences between the Ensign and Teichman types consist in the relative intensity of these forces employed and relative importance of or reliance placed in the three forces named, and in methods of control and operation. Each type has distinctive good points.

Notwithstanding such defects as have been met in plug valves (up to 10 feet diameter), they are believed to be the best regulating valves under great heads now in use, and certainly will be the best when the new models come out. There is no detailed scientific description of these valves as far as known to the writer.

In designing the cylindrical valves now in question there was not in view to devise a valve or type of gate to take the place of the regulating valves, or to be used as regulating valves at all, but to arrive at some type of gate or valve of medium cost, upon the surfaces of which fluid pressures in every direction may be balanced or in equilibrium, to be used as sluice and guard gates under considerably greater heads than practicable for slide gates; and especially adapted for use for guard gates to the Ensign or Teichman regulating valves, and which may be capable of being conveniently operated

under all heads for which slide valves are designed and used. They are not yet (experimental data wanting) considered by me as suitable for use in intermediate positions between open and closed; in other words, for regulating discharge, on account of disturbances that may be expected to be set up by partial vacuums due tortuous course of water through them under high velocities, and the probable hammering due the formation, destruction, reformation, etc., of such vacuums about the edges of the cylinders if not very securely held by close-fitting guides. They can, however, be opened and closed in front of the regulating valves in high-current velocities,

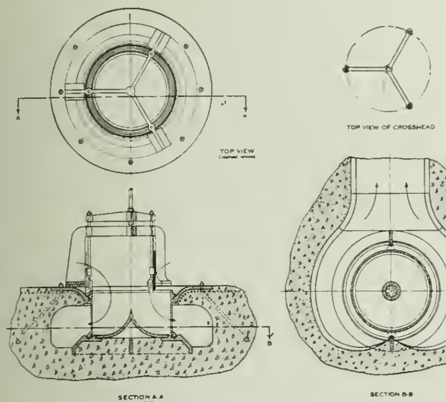


Fig. 3.

if it be found necessary on account of wedging or failure of such valves, under circumstances where slide valves or gates are impossible of operation, and also for emergency discharge gates and sluices, when close regulation is not necessary, or when for any cause the corresponding regulating valve is awaiting repairs. They may all be made water-tight when closed by very simple devices already in use with cylindrical valves.

The single discharge types, and the double-acting valves shown in concrete setting are designed for small heads mainly, but in all types, except that one shown as attached to a pipe elbow (see Fig. 5), the discharge is through the hollow cylinder, and there is no housing or hood required in any of them as in the Fontaine low cylindrical valves used at Panama and for forty years or more elsewhere in this country or abroad. The drawings show types only, and all minor things, like packing, etc., are omitted to avoid confusion. It is unnecessary to show devices well understood to be common to all close-fitting valves.

None of these valves is in use; in fact, they are novelties published just now for what they may be worth in considering projects requiring guard and sluice gates of large capacity under considerable heads. They will doubtless be used, if found useful and advantageous, otherwise they will remain as part of the record of attempts at solving a serious problem in hydraulic engineering that must be solved in some way. The writer believes that the slide gates for large sluices, and for guard gates, under high pressures must go, and that some form of plain, positively operated cylinder or balanced gate will be substituted therefor for closing outlets greater, say, than 20 square feet under high heads, but any of the known cylindrical valves may be made automatic if the expense justifies.

Of the valves proposed herein one form only is of any considerable interest, that is, the "double entry" valves (Figs. 1 and 3), wherein a section of a hollow right cylinder with circular bases is inserted in an annular housing, and closes or opens the inner sides of the inclosing hollow ring. When the cylinder (supposed submerged in water) is raised from its seat a distance equal to one-half or more of its diameter, the liquid discharges into the hollow ring and out through the discharge pipe not only through the interior of the hollow cylinder, but also through the hole at the bottom of the ring heretofore closed by the surface and the base of the cylinder, giving a discharge equal to that of two orifices of capacity equal to the inner section of the cylinder. This form is interesting in two ways:—

1. It may give the greatest possible discharge with the least possible valve movement, and with minimum weight of moving parts and with least frictional resistance. 2. Under very high heads the disturbance at the bases of the cylinder and in the ring might be found dangerous to the material and the surface of the caning might be rapidly eroded by gritty water under the increased velocities, if the full discharge under such head were allowed to pass the valve. In such case the velocities in the valve and casing can be cut down to any extent by reducing the size of the discharge pipe so as to cut down the discharge through the valve itself when wide open to well below the capacity of the valve under that head.

Thus, if the valve were barely capable of safely and smoothly discharging to it full or duplex capacity at 100-ft. head, and it be in question to use it at, say, 400-ft. head, under which head the velocity would be

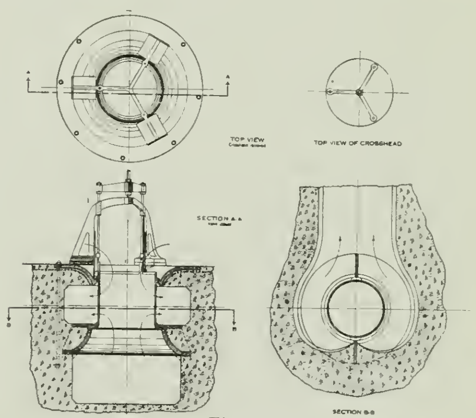


Fig. 4.

doubled and the wearing energy quadrupled, it would be necessary for safe and smooth action to reduce the capacity of the discharge pipe to one-half the capacity of the valves under the full head of 400 feet. This would result in bringing down the velocities, pressures, etc., in the valve and casing when fully opened to the same values as at 100-ft. head, with precisely the same discharge, the velocity in discharge pipe being doubled and the capacity of the pipe at same time reduced one-half.

In similar manner the valve may be adjusted to its greatest safe discharge capacity, at any head, by adjusting the capacity of the discharge pipe or conduit.

The valve is, therefore, practicable through a wide variation in maximum heads due its position in the reser-

voir, by varying the discharge pipe to give equal discharges at such varying maximum heads, or positions. Other types, of course, may be treated likewise, but under similar conditions of adjustment, etc., the form in question will always give approximately twice the discharge of any other type of cylindrical valve of same diameter.

Referring to the drawings, Fig. 1 shows a balanced valve for high or low heads, giving maximum discharge with minimum material and with least movement possible in proportion to discharge. The moving part is a section of a right cylinder, open at both ends, and actuated positively by hand or otherwise. When valve is lifted through a distance equal to or greater than the radius of the interior of the cylinder (if submerged) the liquid in which it is immersed may discharge: 1. Through

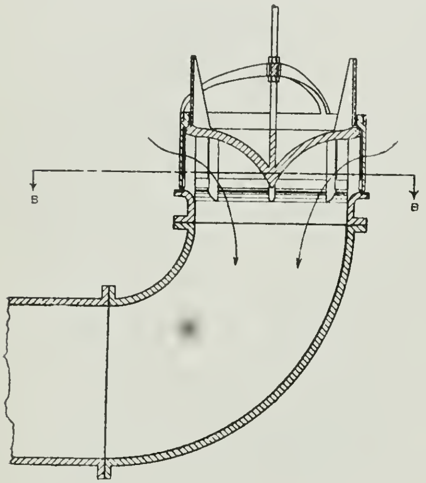


Fig. 5.

the unobstructed interior of the cylinder. 2. Through the orifice at its base, giving thus a discharge equal to that obtained through two cylindrical valves of same size of orifice.

If r be radius of interior of valve and of valve seat and R be radius of discharge pipe, then $2\pi r^2 = \pi R^2$ or $R = r\sqrt{2} = 1.414\, r$.

For instance, if the moving clinder be 5 feet in diameter, the discharge pipe must be at least 7.07 feet in diameter.

The drawing shows essential parts only, but is readily understood. The valve may be made of many forms and of various materials. Inasmuch as the pressures in the valve produce stresses of tension only, the barrel or cylinder may be of ordinary thickness of boiler plate, with flanges if necessary for valve seats. If its weight be counterpoised the valve may be very easily moved by any positive acting force.

To increase efficiency of valve and prevent possible violent shocks under high heads suitable deflecting valves may be constructed in valve casings.

Fig. 2 shows a design for a hoodless cylinder valve discharging through one end and under the other end of an open cylinder, which constitutes the movable part of the valve.

Fig. 3 illustrates a balanced valve of the same type as that shown in Fig. 1, only showing the application of the valve to a setting in concrete.

Fig. 4 is similar to Fig. 2, except that it also shows the valve in a concrete setting. Fig. 5 shows another application of the hoodless cylinder valve, this time to a setting on a pipe below.

All these valves are proposals of Gen. Marshall for the Reclamation Service. In connection with their presentation, he submits the following cautionary notes respecting large valves:—

(1) Care must be taken that the valve is balanced in direction of its axis, to insure ease in operation.

(2) Valve seats may better be separately constructed rings, carefully machined to fit, and attached to valve castings. They may be of other material than the exit conduits.

(3) The guides, side bars, etc., should accurately fit and be sufficient in number and strength to prevent balloting or vibration of the cylinder when wholly or partly raised.

(4) The bails for manœuvring the valve and as guides to tail or lifting rod should not obstruct the approach of the liquid to the cylinder, which obstruction may increase the force required to manœuvre the valve.

(5) The surfaces of approach and exit to and from the valve may be such as to facilitate and increase the discharge, but such refinements should not be practised where the gain will not justify the cost.

ACCIDENTS IN MINES IN QUEBEC.

During the year 1913, there were 8,611 persons employed in the mines, quarries, clay-pits and concentrating mills of the Province of Quebec. This number is not the actual number, which was somewhat higher, but it is a reduction to a basis of 300 days work per man per year, from the actual number of days work performed, which totalled 2,583,673. The total sum paid in wages during the year amounted to $5,401,702, or an average of $626 per person per year. This may perhaps appear low, but it must be considered that all the mines and quarries are situated in the settled parts of the province, where unskilled labor commands a much lower rate than in the average northern mining camp, and also that a certain proportion of the employed are signal-boys in the asbestos open pits, girls in the mica trimming shops, and in the asbestos sorting sheds.

Throughout the year, sixteen deaths occurred through accidents in mines, quarries, clay pits, in the province. Taking the basis of 8,611 persons employed, this gives a general proportion of 1.86 per 1,000 men employed. In the mines proper, asbestos, copper, graphite, mica, etc., the proportion was much higher; of 3,444 men, 11 were killed, or a proportion of 3.19 per 1,000 men employed. In the quarries proper, clay pits, brick-yards, etc., there were 5,167 persons employed, 5 of whom were killed, or a proportion of 0.97 per 1,000 employed.

BUFFALO RAILWAY TERMINALS.

Railway terminal work in Buffalo, N.Y., calling for an expenditure of $15,000,000 to $17,000,000, will be placed under construction in the next year or two. Plans for a new station and other improvements for the Lehigh Valley, to cost about $5,000,000, have been approved by the Buffalo Terminal Commission. The Lehigh facilities will be shared by the Grand Trunk, Erie, Nickel Plate and Wabash. The New York Central lines are developing a scheme for a new terminal, which according to present plans will cost close to $10,000,000. In addition work is now progressing on the new Lackawanna station which will cost about $2,500,000.

On July 11, the Port Dover Brick and Fire Works were destroyed by fire, entailing a loss of $20,000. It is proposed to rebuild the plant next year.

COMPRESSION MACHINE FOR TESTING STRUCTURAL MATERIALS.

With the increasing recognition of the necessity for laboratory tests of concrete has come a demand for a simple machine for testing the compressive strength of specimens as large as 8 and 10 in. in diameter. Engineers and builders are beginning to appreciate the fact that a great deal of money can be saved on a large concrete job, amounting often to thousands of dollars, by proper selection and proportioning of the aggregates. To compare the qualities and proportioning of different materials, it is necessary to make fairly large concrete specimens with the cement and aggregate to be used on the work. Advance tests are also essential from the standpoint of safety, and to determine the allowable working compressive strength of the concrete in a reinforced-concrete structure.

In addition to these tests of specimens made in the laboratory, it is now required on important construction that blocks of concrete shall be made up in the field at stated intervals, and tested for compressive strength at ages of, say, 7, 14 and 28 days.

Compression machines of from 100 to 150 tons capacity for testing concrete specimens would be in much greater demand were it not for their high cost and their bulkiness. There are two types of compression machines on the market: Screw machines and hydraulic machines. For very large work the screw machines are preferred to the hydraulic machines; but for small work, the former have the disadvantages of high cost, heavy weight, large floor area required, and mechanical power necessary to operate.

The hydraulic machines now on the market lack some of the objectionable features of the screw type, being less in cost and in weight, requiring less floor area, and being generally operated by hand. However, they are still out of the reach of the smaller laboratories and of construction jobs where concrete specimens of 6 or 8 in. in diameter are made up for testing. The small hydraulic machines on the market at the present time within the reach of laboratories and construction jobs from the standpoint of cost and size, are not of sufficient capacity to test specimens of mortar or concrete larger than 3 in. or less in diameter. To obtain a good average sample of concrete, specimens should be cast at least 6 in. and preferably 8 in. in diameter. A machine to test specimens 8 in. in diameter must have a capacity of at least 100 tons. A capacity of 125 to 150 tons is still more preferable as affording a slight excess capacity and also providing for cases where it is desirable to test an old piece of concrete such as is sometimes cut from a wall. Such a piece, even after sawing the faces true in a power saw, is apt to be irregular in shape and may run a trifle over 8 in. in one dimension.

With a view to obtaining, particularly for tests of mortar and concrete, a reliable, accurate, and efficient machine of a capacity up to 125 tons, at a low cost, and requiring comparatively small floor space, a design was developed by W. H. Weston, under the supervision of Mr. W. O. Lichtner, consulting engineer, Newton Highlands, Mass., and described by the latter at the recent convention of the American Society for Testing Materials. His description is as follows:

This machine consists of an ordinary hydraulic jack like those used in ship-yard work, set in a frame consisting of a heavy base and top. The top of the frame is provided with a head block having a ball-and-socket joint with about ½-in. play in the joint, so as to adjust itself to the specimen and give it a square bearing.

To cover the range required by small specimens of mortar and large blocks of concrete, two gauges are necessary. These gauges are calibrated to read the total pressure on the ram. The small gauge registers up to 20,000 lb. by 100-lb. intervals, and the large gauge registers up to 250,000 by 1,000-lb. intervals, with possibility of interpolation for finer readings. Specimens of small sectional area will break under a comparatively small load on the ram, so it was desirable to be able to take readings by 100-lb. intervals when reading on the small gauge. When the pressure on the ram exceeds 20,000 lb. the stop-cock on the small gauge is turned off, which prevents any further pressure coming on this gauge. This arrangement has been found to work very satisfactorily. Both gauges are equipped with a "maximum hand" which consists of a wire held on the main stem of the gauge hand by a spring in the form of a bent wire. This leaves the wire loose enough to be pushed around the dial of the gauge, but not so loose as to be jarred out of position when the specimen breaks. The top end of the wire is bent outward so as to be caught by the gauge hand as it moves around the dial when the pressure is applied. When the pressure is released, the gauge hand returns to zero and leaves the maximum hand to indicate the pressure which was reached when the specimen broke. The gauges have been carefully calibrated and register accurately at all points.

In order to protect the large gauge from the sudden release of pressure occurring when the specimen breaks, it was found necessary to design a check valve to be inserted in the pressure line to the gauge. This check valve consists of a small valve seated by a spring. When the pressure is applied, it forces the valve against the spring, allowing the water to pass into the gauge. When a sudden release in pressure takes place, the spring seats the valve and the water in the gauge gradually runs back to the pump by means of a very minute by-pass, which is in reality only a small scratch on the seat of the valve.

The jack is equipped with a single-stroke compound pump. The large plunger is used in raising the ram to a height sufficient to tighten the specimen in the machine, and then this plunger is thrown out of service, which allows the small plunger to operate. The large plunger raises the ram about 0.08 in. per stroke, while the small plunger raises the ram about 0.02 in. per stroke. The load should be applied to the test specimen uniformly. This cannot be accomplished with quite the same uniformity in a hydraulic machine that can be obtained in a screw machine on account of the upward stroke of the pump handle. It has been found, however, that with care the pump can be so operated as to apply the load very evenly and without a jerk, and that by making a quick return stroke of the handle the pressure may be considered as being increased continuously. In applying the load, the ram should be raised at the rate of 0.026 ft. per minute, which can be done by operating the pump handle so as to make a stroke and return in 3½ seconds. A clock arrangement is being devised to strike every 3½ seconds, so that the man operating the machine can accurately regulate the pumping. When the load on the ram reaches the vicinity of 125,000 lb. or over, a pipe extension about 3 ft. long is put on the end of the 3-ft. pump handle. This gives the operator the necessary leverage to operate the pump without the assistance of another man.

A guard should be placed around the working parts of the machine to protect them and also the operator of

the machine from injury when the specimens break. Concrete specimens having a height twice the diameter often break very suddenly, throwing small pieces of the specimen around in all directions.

The frame of the machine measures 20 by 32 by 60 in. high, outside dimensions, and the total weight is about 1½ tons.

The machine described has been in operation now for some time and has been found to give accurate and reliable results. The results have been checked several times by a series of check tests on a large expensive screw machine.

THE PREVENTION OF THE SUBCRUST MOVEMENT IN ROADS.

THE behavior of roads subjected to heavy traffic has been under the observation of road engineers everywhere, and in several instances certain experiments have been initiated to determine, as far as possible, the lateral and longitudinal movement of material forming the subcrust of highways. One of the investigators, Mr. E. S. Sinnott, M. Inst. C.E., county surveyor of Gloucestershire, Eng., read a paper before the recent Cheltenham convention of the Institution of Municipal and County Engineers, concerning his work. It is largely descriptive of observations made as a preliminary to more precise investigation under way, the former comprising the opening and inspection of various sections of grass verge adjoining the principal roads.

Speaking generally, these indicate that lateral movement, in some instances to a considerable extent, has been taking place, and such movement seems to call for special consideration.

The following examples will serve as illustrations: (i.) On main road (Gloucester to Bristol) at Whitfield, near Falfield. At this point the grass verges were opened on both sides of the road, and on the west side there was found, at a depth of about 4 in., a bed of broken limestone having a width of 3 ft. from the metalled surface, varying in thickness from 7 in. nearest the road to 4 in. at the 3 ft. distance. On the east side a somewhat similar state of affairs was found to exist, the width in this case being 2 ft. 6 in. from the verge. The subsoil is a hard, red clay. (ii.) On main road (Bath to Malmesbury) near Chipping Sodbury. In this instance the lateral thrust is shown in the movement of a line of channelling formed of three stones on edge put in to protect the foot of a bank: originally laid with a horizontal face of 13 in. in width, the stones having been forced into a vertical position, having moved through an angle of 90 deg. In several instances the upper stones have been forced completely over, having rotated through an angle of 180 deg., and have fallen backwards into the highway, their movement away from the road being arrested by the bank they were put in to protect. The subsoil is clay.

(iii.) On the main road (Gloucester to Bath) between Hardwicke and Stonehouse. In this case metalling and pitching have been found from 3 ft. to 5 ft. from the metalled surface, and about 18 in. in thickness. The subsoil consists of clay and sand.

(iv.) On the main road (Cirencester to Cheltenham) at Baunton Hill. The opening at this place showed that the original pitching and oolite macadam had been forced for a distance of 4 ft. from the edge of the metalled surface, the outer end showing an upward movement. The subsoil is clay.

The results above described indicate generally the position of affairs upon roads where traffic is heavy, although in a small minority of cases investigated little or no movement could be detected. It appears evident, however, that where lateral spread does occur it cannot fail to be ultimately destructive, as without substantial and immovable support the top coating cannot be kept up to its work, particularly after some wear has taken place, and it becomes a question how far new surfaces of an expensive character are justified before the subcrust movement referred to has been arrested.

With a view to obtaining more accurate information, the writer has lately placed a number of iron bolts below the surface of certain roads, and has fixed their position exactly by steel tape measurement, so that any movement can be definitely ascertained on a future occasion.

He has also inserted measuring instruments at various places, which consists of two rods arranged to slide one over the other, having iron plates at their outward extremities, which will enable any movement, either lateral or longitudinal, to be recorded.

As a means of preventing the action above described, the writer has recently designed and put into use a rigid framing, the essential feature of which is that longitudinal and cross members placed at a suitable depth below the surface preclude any movement of the subcrust, and at the same time provide a means of constructing an impervious arch of tarred macadam to carry the traffic, great additional strength being provided by the longitudinal members for the support of the heaviest road vehicles.

For various reasons, the writer thought it best to construct the frames in reinforced concrete, although timber or other material could, if preferred, be used.

The longitudinals are 12 in. by 3½ in. (average thickness) by 12 ft. long, and are slightly tapered from top to bottom. The ends of the longitudinals are securely housed at the extremities of the cross-ties.

The reinforcement consists of expanded metal 3 in. mesh ¼ in. by 3-10 in., weighing 11½ lbs. per superficial yard, cut into strips 9 in. wide—in the case of the cross-ties this is supplemented in a minor degree with wrought iron round bars of small section at the ends of the same.

A further modification consists of making the longitudinals slightly curved on the inside, in order to withstand lateral thrust more effectively; also, where difficulties due to traffic may be anticipated, in placing the cross-ties in position they can be made in two parts and connected in the centre with a bolt or bolts.

In the experimental frames which have been put down, the width between the longitudinals has been fixed at 8 ft., but there is no particular reason for adopting this dimension, other than that it appears suitable for dealing with the traffic conditions of rural roads in Gloucestershire, where most of the heavy weights are carried in the central portion of the highways.

If considered advisable, a greater width than 8 ft. may be adopted between longitudinals, or where traffic conditions justify it, the central pair can be supplemented by longitudinals on either side, connected thereto by cross-ties similar to those previously described.

The frames have been placed, the top edges of the longitudinals being 6 in. below the finished road surface, which, from the information at present at the writer's disposal, appears the most suitable position for arresting the lateral movement, also at this depth there would be little or no interference with pipes, and with 6 in. cover over the top side of the longitudinals there appears to be sufficient cushion to avoid any damage thereto.

Editorial

EXPERIMENTS WITH ROAD MATERIALS.

An English contemporary has the following to say about research experiments in connection with highway engineering: "Is it not time some one entered a protest against the waste of money in a lot of laboratory experiments on road material? The results of these tests are about as valuable as a knowledge of the canals of Mars. The sum and substance of road work is summed up in one word—'conditions.' Two roads constructed similarly of like materials, but upon the two opposite sides of a hill, will wear differently, and no amount of laboratory experiments will alter the fact. Again, a material which will serve admirably in an open country will not wear similarly if used through a woody, damp district. Further, there are materials admirable in certain positions used on the flat which are useless and dangerous if used on a gradient.

"This flinging of laboratory experimental results is a fad of faddists wanting to stereotype practice and to issue red-tape orders from a central office as to what is to be done in every corner of the land. Standardization and red tape are refuges for the destitute in common sense and the conceited empiric who believes that the result of an experiment upon granite, syenite, slag or other material is a solution of the problem where and when they should be used. No laboratory experiments will give relative values of various methods of road surfacing unless all the varying conditions of climate, soil, gradients, aspect, surroundings, character of traffic, etc., are known. The factors in the problem are too numerous to be solved by a laboratory experiment. You cannot get even some preliminary indication of probable results in the laboratory. The question of standardization is a wider one, but in most cases the result is to stereotype practice and to prevent men using their brains. It assists the degeneracy of a profession. There is no incentive to progress. What is, is, and is good enough."

What is, is not good enough; hence the field of experimental research. To ascertain, by experiment, the materials best suited for the conditions which prevail on either side of the hill, or for the conditions to be found in open country, in woody and damp districts, on the flat or on a gradient, entails the expenditure of some money, of course. But the saving to the country as a result of such experiments, and the comfort and other benefits that also accrue, cannot be reckoned in dollars and cents. The difference in cost of maintenance (and even of construction) between the scientific methods that are being so keenly investigated and the rule-of-thumb practices that have too long prevailed will be as evident, a few years hence, as a result of experimental research, as it has in so many other phases of municipal development.

"PROPOSED RAILWAY VIADUCT, TORONTO."

In view of the many arguments favoring the electrification of steam railways within city limits, as well as other points which it raises for consideration in connection with the proposed railway viaduct along the waterfront of the City of Toronto, we publish on another page a discussion submitted by a well-known consulting engineer and railway manager. Apart from the electrification feature, the question of clearance is one that merits further attention, as so much expenditure hinges upon it in an undertaking of this kind. Doubtless those not conversant with Canadian railway specifications will be surprised to learn that the requirement of 22 feet over top of rail, as in force in this country, is higher than any similar requirement in the United States or Great Britain.

CONSIDERATION OF TENDERS.

Tariffs are imposed on nearly all lines of importation into Canada, designed to equalize conditions between Canadian firms and foreign firms. When a foreign firm answers a formal call for tenders, and underbids a Canadian firm, despite the duty burdens imposed upon the foreign firm, the Canadian firm has no right to expect favoritism merely upon the made-in-Canada argument. Should the Canadian firm be able to make better deliveries or should the quality of its product be superior, then it is entitled to prior consideration even though its tender be higher, but not too high in proportion to the greater service it is prepared to render.

To a far less extent is any one section of the Dominion warranted in favoring local firms at higher figures in preference to other Canadian firms more distantly situated. The city of Vancouver recently bought a number of valves. Three tenders were finally considered. A United States firm bid \$8,405; a Walkerville, Ontario, firm bid \$8,485; a British Columbia firm bid \$9,700. The waterworks engineer and superintendent recommended the acceptance of the Walkerville tender. The waterworks committee of council favored the lowest tenderer, but the city council—by the mayor's vote—awarded the contract to the local firm.

This is dangerous practice, but in line, so far as engineering ethics are concerned, with other recent actions of the same council. It is reported that there is a general campaign in British Columbia in favor of using home-made goods in preference to goods made in other provinces or countries. This is said to be urged in the matter of requiring contractors for the Second Narrows Bridge across Burrard Inlet, which will cost approximately two million dollars, to specify that British Columbia-manufactured steel be used in the construction. The adoption of such a policy would have a very depressing effect upon British Columbia's credit in the money markets. Petty, narrow-visioned economics of this sort will surely not be allowed to prevail in the province that is ordinarily the most unselfish in Canada.

Before the United States Senate has appeared Senator Bryan's good roads bill, under the terms of which the federal government would issue 3 per cent. bonds to the amount of \$500,000,000 in instalments of \$100,000,000 each for 5 years, for road development. Before States could participate in the funds they would be required to issue an equal amount of 4 per cent. bonds, which, when deposited in the treasury department, would be exchanged for cash. The 1 per cent. difference would make up a sinking fund to aid the States in retiring the bonds. Creation of federal highway commissions to supervise the expenditure of highway funds is a feature.

PRODUCTION OF STRUCTURAL MATERIALS FROM QUEBEC MINES DURING 1913.

THE structural materials appear for a preponderating part of the total value of the mineral production of the Province of Quebec. In 1913, their value amounted to $8,187,917, which represents 62 per cent. of the total production. Under this heading are grouped cement, limestone, brick, granite, lime, building sand, clay products (tiles, drains, pottery, etc.) in the order of their importance. The following information is from the report for 1913 of the Mines Branch, Department of Colonization, Mines and Fisheries:—

Cement.—The cement manufactured in the Province of Quebec is exclusively Portland cement. The manufacture of cement is now an exact science, and it is almost impossible to find a natural mixture of clay and limestone which will give the results expected from a Portland cement. The natural cement industry in Canada has been entirely replaced by the manufacture of Portland cement, in which the raw materials are mixed in fixed proportions, according to a strict chemical control.

The composition of Portland cement is, therefore, definite, and, although the mixture of raw materials may vary within narrow limits, it should normally contain 75 per cent. of lime carbonate, 13 per cent. silica (soluble), 5 per cent. alumina, 1½ per cent. iron oxide (Fe_2O_3), and the remainder allowed for impurities, magnesium carbonate, alkalis and inert substances. The raw materials used in the Province are Trenton limestone exclusively, for the lime constituent, and Utica shale, or Leda marine clay, for the argillaceous component. These substances are very abundant. All along the north shore of the St. Lawrence River deposits of both limestones and clays are common.

In 1913, the cement mills of Quebec shipped 2,881,480 barrels, valued at $3,361,292. In fact, the value of the cement production was over 40 per cent. of the total value of the structural materials. Ten years ago, in 1904, the recorded production of cement of our province was 40,000 barrels, valued at $66,000.

Limestone.—The limestone industry is well developed in the vicinity of Montreal, where quarries have been opened at Mile End, at Outremont, Côte St. Louis, Longue Pointe, Villeray, Sault-au-Récollet, on beds of the Chazy and the Trenton limestones, both of which are well developed in the Island of Montreal.

At St. Vincent de Paul, St. François de Sales, where a great deal of the limestone is produced, the quarries are in the Trenton. The same formation is also worked at St. Marc des Carrières, Deschambault and Lachevrotière, in Portneuf county, as well as at Beauport and Château Richer, immediately below Quebec. Trenton limestone is also quarried in Hull, opposite Ottawa.

From returns received from producers, the limestone extracted in 1913 reached a value of $1,704,207. This, however, does not represent the whole production, for it is almost impossible to keep track of all the small operators who work spasmodically. From the 162 names of limestone producers to whom we sent return forms to be filled in, only 84 answers were received, many answering only after the second or third request. Of these 84, there were 44 who reported a production, and 40 whose quarries had been idle during the year.

Granite.—The Laurentian area, which extends to the north of the Ottawa and St. Lawrence Rivers, affords an unlimited supply of granites of various colors and textures, but, owing to the limited market, very few quarries have been opened. The main operators in the Laurentian granite are the Laurentian Granite Company, whose quarry is situated at Staynerville, in the county of Argenteuil; M. P. and J. T. Davis, who are working a quarry at Rivière à Pierre, north of Quebec, the stone being used altogether in the construction of the Quebec bridge.

Another source of granite is found in the various igneous intrusions which penetrate the rocks of Ordovician age in the Eastern townships, and large quarries on such occurrences are worked in the township of Stanstead; in the township of Whitton; on Mount Johnson, near Iberville Junction. The production of granite reached $496,588 in 1913, as compared with $358,749 in 1912.

Other Structural Materials.—There are no new developments in the other materials of construction. Brick and lime show very small increases as compared with the previous year, which may be accounted for by the fact that concrete construction is on the increase, as shown by the large increase in the production of cement. The sand which figures in the table of production only represents a very small proportion of the sand actually used in building operations, as we only keep record of the sand which is worked under mining licenses. Most of this sand is dredged or pumped from the beds of rivers.

PROGRESS ON THE C.N.P. RAILWAY.

A recent statement made by D. O. Lewis, divisional engineer of the C.N.P. company in British Columbia, announces that the work being done between Parsons Bridge and mileage 100 will be completed by the last of August. Mileage 100 is a point about 4 miles from Cowichan Lake and about 5½ miles from the Nitinat River. This means that before the end of next month the grade for over 100 miles will be ready for the sleepers and rails. The steel bridges, which are to be put at mileage 54, 68, 73 and 75, will be constructed as the rails are laid. The grade from mileage 100 to mileage 121, a point in close proximity to Alberni Canal, will probably be completed at the end of the year.

From mileage 121 to mileage 136½ the road is practically finished. Mileage 136½ is within 6½ miles of Alberni, so that, when the line from mileage 100 to 121 is finished, the road will be in condition for the rails as far as Alberni.

The wooden bridges beyond mileage 101 will not be built until all the grading is done and the rails are laid so as to avoid danger of their destruction by fire.

The line which will run from Patricia Bay down the Saanich Peninsula, round Swan Lake and Portage Inlet to Parsons Bridge, has been almost completed as far as the grading is concerned.

At Patricia Bay, where the rails are to be landed, a contract for the erection of the approach and pier has been awarded to S. Doe, of Victoria. The work is to be completed in 70 days. The steel for the small bridges will probably come from Vancouver; that of the larger structures, from Eastern Canada. The first cargo of steel will arrive at Patricia Bay between October 10 and 15; and another shipment is expected by the middle of November. These two cargoes will be sufficient for the road to mileage 100.

Plans are being prepared and considered in Denmark and Sweden for a channel tunnel between the two countries. The greatest depth at which the tunnel will run will be about 100 feet, and it is estimated that the undertaking can be completed in 5 years at a cost of about $25,000,000. The tunnel will be worked by electricity, and will be driven through the stratum of grey chalk underlying the northern European continent.

MOVABLE CRESTS FOR DAMS.

THE accompanying drawings show some types of automatic and hand-controlled flashboards, intended for use by the U.S. Reclamation Service. They were proposed by Gen. William L. Marshall, consulting engineer to the Secretary of the Interior, were described in an article in the May number of the "Professional Memoirs" of the Corps of Engineers, U.S. Army. The author calls attention to the fact that the two types shown at the top of the drawing are new but were patented by him some years ago, the straight or plane gate type (upper left-hand figure) having been in use since 1907 on one of the feeders of the Illinois and Mississippi Canal. Altered to suit local conditions, it is placed horizontally in the bottom of the feeder as an emergency stop gate, to rise and retain the canal level in case of a break in the banks. The particular gate was designed by Christopher Holth, mechanical engineer, and constructed by L. L. Wheeler, assistant engineer. The canal bank broke in 1910 and the gate automatically rose and closed the feeder, retaining the level in the feeder canal. It then repaid its cost.

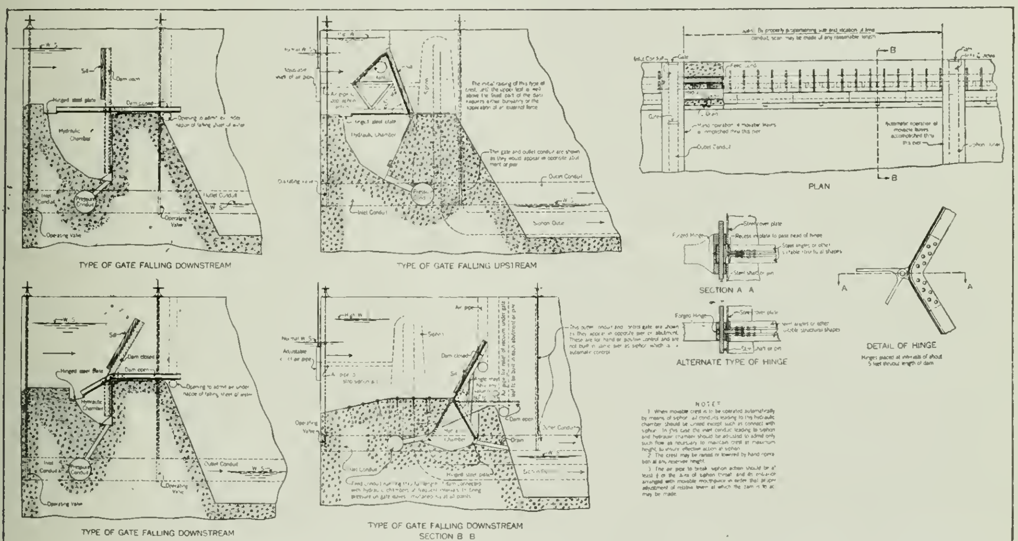


Fig. 1.—Types of Movable Dam Crests.

The second type, at the top of the drawing (without the wooden drift shield and siphon), has also been in use since 1907 as upper gates on fourteen locks on the Illinois and Mississippi Canal, but the lower leaves or aprons of those gates were designed of sufficient size only to depress the gates automatically when the locks are filled to within 10 in. or less of the surfaces of the upper pools. Those gates have worked successfully since 1907, although there were defects in workmanship that were corrected, and at least one uncorrected defect in design that is of no practical importance so long as the canal levels are maintained. These gates were also designed under General Marshall's patents by Christopher Holth, but the completed designs were not submitted to him for correction. This type requires flotation or auxiliary power to raise it until its nose is above water, when the current may act. It may be readily modified to be applicable to spans up to 100 ft., but is peculiarly adapted for use as an upper gate to a canal lock of 40 ft. or less span and not exceeding 10 to 12 ft. depth.

Later Types.—The two types at the bottom of the plate are believed to be novel, and have now been published for what they may be worth. They may be used by the United States freed from patent claims. Any one familiar with bear-trap dams will understand at a glance their working. The only features worth special remark are:—

1. The care taken to so arrange the hydraulic chambers as to cause mud and sediment to be swept by the motion of the gate into or near numerous water supply and exit pipes or "scruppers," and sufficient leakage to keep mud from accumulating. This leakage may be reduced to any extent by well-proved means.

2. The arrangement of piping for above purposes, and to secure uniform distribution of water pressures along entire length of gates by making main conduits of much greater capacity than that of all distributing pipes or conduits combined.

3. The siphon for automatic control of the gates during floods, in connection with, or rather, in addition to, hand control. These siphons "bleed" the supply mains before water in them may reach under pressure the small distributing pipes leading into hydraulic chambers, and have discharge capacities nearly equal to, but less than, the main conduits, so that (if the hand-operating devices be closed) whenever during a flood the water level above a dam reaches the level of the siphon throat or top, the siphon at once so "bleeds" the supply main that the preponderance of water pressure is at once changed from one side to the other of the axis of rotation of the gate, and it will fall and remain flat until the level in the reservoir falls below the air inlet to siphon, whereupon the siphon action is broken, the full pressure is again exerted

throughout the surface of the gate, the preponderance of pressure is again shifted from one side to the other of the axis of rotation, and the gate rises.

The type with siphon control falling down stream admits trussing or bracing, etc., so that it is possible to make it very light and at the same time strong and stiff against warping and of any reasonable length. It may be advantageously used up to 10 to 12 ft. lift on high spillways and dams. The width of that part below the axis of rotation in any of these movable crests should be not less than five-eighths the width of upper section, exclusive of width of flap leaf; the relative proportions of parts of gates should be computed to meet the special conditions in each case.

Steel plates are hinged to edges of lower sections and move along inclined planes in order that there shall be elasticity in the system even under considerable wear at axis and inaccurate work. The gates will not be subject to wedging and obstruction by gravel, chips, etc., and these narrow leaves remove most of the objections that have been made to drum weirs, etc., the leaves of which must be nearly in contact with the curved surfaces of hydraulic chambers, and are often wedged. These plates may be in sections of desirable lengths, the joints between lengths may be stopped against leakage by strips of pure rubber packing, allowing any section to rise or descend enough to pass over any chance pebble or chip without serious leakage, or straining the gate, and the plates as a whole to adjust themselves to wear or inaccurate workmanship, location of axis or informing the plane surfaces of the hydraulic chamber.

4. The air passages to remove vacuums that form under the gate, due to rapid flow of water over it when down, are not novel except in the particular disposition of them. Vacuums more or less complete under overfalls increase materially the pressures on the upstream faces of gates and dams; cause tremblings and vibrations in dams, and in old bear-trap forms sometimes determine whether they can be worked at all in certain positions or phases of their motion.

The question of prevention of partial vacuums, then, is of some importance in all dams, whether movable or fixed, and especially so in bear traps, where little or no attention has been given the subject.

Regulation of Levels of Reservoir With Spillway Crests and Sluiceway Gates.—Some criticisms of automatic movable sluice gates have been based upon the opinion that their movements are so rapid that there would be thrown into the stream below the reservoir large amounts of water en masse, thus creating waste of such magnitude that damage to animal life, or to property, might result.

This objection is well founded, but, when it is considered that the movable crests, or spillway gates proposed are in fact hydraulic engines, capable, if properly constructed, of as smooth, gradual and certain movement and control (and by similar methods) as any other hydraulic press or engine, the point is of small importance.

It is necessary for this purpose in a series of sluiceways controlled by automatic gates to provide one and only one sluiceway of the series, with a hydraulic gate to be operated carefully by hand, in order to make the increase in discharge as gradual as it would be over a fixed or movable horizontal weir of suitable length, by filling in by gradual increase in discharge the differences in total discharge caused by the sudden periodic gate movements.

For instance, suppose there is an available site 350 ft. in length for a spillway to be used in connection with a large reservoir, and that the maximum flood to be wasted is about 25,000 sec.-ft. and it be desired to store all water practicable in the reservoir, with a fluctuation in its water level of about 2 ft.

The effective depth of the sluiceways, if 50 ft. wide each, must be 9 ft. at maximum flood level, and there must be six of such sluiceways of that width to discharge the maximum floods of 25,000 sec.-ft.

The sluice gates or movable crests may be made of 7-ft. lift each, and the water levels in the reservoir must be so controlled as to rise not more than 2 ft. above their crests when raised.

Each 50-ft. sluiceway 7 ft. deep will discharge approximately 3,000 sec.-ft. When the water rises to the limit assumed there will be 9 ft. depth in the sluices and the discharge of each will then approximate 4,500 sec.-ft. The discharges may be less than above given, but they are assumed for the purposes of a demonstration; accuracy is not now in question.

One of the sluice-gates is to be of most careful construction, and fitted in all its parts for hand control and operation, and five of them are supposed to be operated automatically by siphon, all gates being of a type falling down stream from the reservoir. These latter have the siphon throats and their air-entrance breaks adjusted in level so that the gates will fall in succession, upon increments of, say, about 3 in. in reservoir levels, beginning with the first gate falling when that level reaches 7 in. above the crest when raised, and the last or sixth gate falling when the water level of the reservoir is about 3 in. below the maximum safe limit named above. Now, when the water level in the reservoir rises until it is nearing 7 in. above the crests of the gates—at which level the first gate is arranged to fall—the operator would begin to lower the hand-operated gate at a rate that preserves the level of the reservoir water until that gate be fully depressed.

Whenever the first automatic gate goes down, the hand-operated gate should at once be raised, and the same gradual movement of the hand-operated gate be resumed between the falling of the first and second, etc., and succeeding automatic gates, if such care be necessary. It is, then, practicable to make the discharge from a reservoir by the use of these gates, or indeed of any of the "bear-trap" family, as gradual and regular as by any other device, even if that device be a fixed weir, but the controlled sluiceways have the material advantage over the fixed weir of allowing the storage of 7 ft. (in this case) depth of water over the entire surface of the reservoir, which cannot be done by a fixed weir of same length of crest with as little waste and as little fluctuation in water level in the reservoir, and the sluices moreover, serve admirably for drift chutes.

In some very large reservoirs now in existence, or under construction, this additional storage of 7 ft. in the reservoir might run to a hundred thousand acre-feet or even much more, a matter of very great importance in our arid region, where water is so precious for irrigation and domestic use.

EXPLOSIVE PRODUCTION.

The United States Bureau of Mines has compiled some figures on the production of explosives in the United States in 1912. It appears that there were manufactured, 230,233,369 lbs. of black powder; 24,630,270 lbs. of permissible explosives; and 234,460,402 lbs. of high explosives, such as dynamite, nitroglycerine, etc. Of the high explosives, 89,703,081 lbs. were consumed in mining other than coal and 4,668,399 lbs. of permissible explosives in the same industry.

ELECTRIFICATION OF STEAM RAILWAYS.

IN *The Canadian Engineer* for July 9th, 1914, appeared a discussion of the steam railway electrification problem, by Mr. J. A. Shaw, of the Canadian Pacific Railway Company. The following, extracted from a paper read by Prof. D. D. Ewing before the Indiana Engineering Society, will be found of particular interest, as the statements advanced by both authorities leave little to be desired in the matter of general information respecting the systems that have received practical recognition. Prof. Ewing states that power companies are interested in electrification because they have electrical energy for sale. The railway companies can build and operate their own power plants, but in many cases they find it cheaper to buy energy than to generate it, the low ratio of average demand to maximum demand making a railway load alone rather unprofitable for a power station.

As far as the power station and transmission lines are concerned, nearly all systems of electric traction are similar, consisting generally of three-phase power generation and high voltage and three-phase transmission. It is in the motive power equipment and the distribution systems that the differences come. Four systems are finding practical application to-day.

Direct-Current System.—In this system direct-current series motors are used on the locomotives or motor cars and voltages ranging from 600 to 2,400 volts are used on the trolley or third rail. The trolley or third rail and its feeders receive direct-current energy from substations located at intervals along the right-of-way. In the substations, transformers and rotary converters change the high-voltage three-phase currents of the transmission system to direct current at the proper trolley voltage. This is the well-known system used on street railways, modified to meet the demands of steam line traffic, and up to the present time has found wider application in this country than all of the other systems put together. Of interest in connection with this system is the recent announcement that the Chicago, Milwaukee and Puget Sound Railway has decided to use it in its electrification over the Rocky Mountains.

Single-Phase System.—Either series or modified repulsion type, single-phase motors are used on the locomotives or motor cars. The trolley receives its single-phase current supply from transformers, located at intervals along the line, which transform the high voltage of the transmission system to a value suitable for the trolley. Trolley voltages range from 3,300 to 25,000 volts, 11,000 volts being common in this country. A balanced three-phase load is approximately secured by dividing the trolley line into sections and feeding the different sections from different phases. Transformers on the locomotives or motor cars step the trolley voltage down to a value suitable for the motors. The motors are rather complicated and have high maintenance charges. On account of the high trolley voltages used, the first cost and line losses of the distribution system are low. The most prominent example of this system, in this country, is that of the New York, New Haven and Hartford Railway.

Three-Phase System.—In this system three-phase induction motors are used on the locomotives, and two trolley wires are required, the track forming the third leg of the three-phase circuit. Trolley voltages up to 11,000 volts have been used. Transformers on the locomotives step the trolley voltage down to a value suitable for the motors.

The two trolley wires required complicate the overhead work, but the motors are simple and rugged. The system is readily adapted itself to regenerative control ot trains on down grades. The motor is inherently a constant speed motor, and will carry its load up grade approximately as fast as it will carry it down grade or on the level. With some modifications in the design of the motor, its speed can be varied in steps without seriously affecting its efficiency.

The Great Northern Cascade Tunnel electrification is the only example of this system in this country, although locomotives having an aggregate rating of about 200,000 h.p. are in use in Europe.

Split-Phase System.—The locomotives are equipped with polyphase motors and single-phase current is supplied from the trolley. A phase converter on the locomotive converts the single-phase energy to the polyphase energy required by the motors. The distribution system is the same as with the single-phase system, and the motive power equipment is the same as with the three-phase system, with the exception of the phase converter. In a measure the good points of both systems are combined. The system is a new one, and is possibly the most spectacular development in electric traction made during the year just passed.

Advantages and Disadvantages of Electric Traction.—The following are a few of the more important advantages and disadvantages of electric traction for railway trains. Briefly, the advantages are:—

The safety of operation is increased because signals are not obscured by smoke and steam, and the locomotive-driver can give his entire attention to driving, and his seat can be located so that he can see both sides of the track at all times.

Regenerative control is possible with all systems of electric traction. With regenerative control the air-brakes are used only in stopping or in case of emergency. Car wheels and brake shoes are not heated by long-continued applications of the brakes on down grades, and the number of wrecks due to cracked wheels is lessened. The energy that would otherwise be used up in heating the brake shoes and wheels is pumped back into the line and helps pull some other train up hill. While regenerative control is possible with all systems, it has not been used on all systems in the past on account of the resulting complication in the control apparatus and motor windings of series type motors.

The dispatcher can stop a train at any time by ordering the power supply shut off from the section in which the train is running, and the control mechanism may be readily arranged so that the brakes are applied automatically if the power is shut off from the trolley.

In mountain grade work, higher speeds may be maintained over the grades than is possible with steam locomotives. Going upgrade, the speed of the steam locomotive is limited because its power output is limited by the boiler capacity. The electric locomotive is not limited in this way, and for short intervals it can carry large overloads.

Powerful motors can be mounted on comparatively light locomotives. While the weight of a locomotive fixes the drawbar pull at starting, its horsepower capacity fixes the pull when running at a given speed. This means that electrically operated trains can be accelerated at much higher rates than steam trains and can be operated at higher speeds over grades.

Electric locomotives require inspection once in from 1,200 to 2,500 miles of operation. To keep steam locomotives in similar condition they must be inspected and cleaned at the end of every run. On those roads which are operating electric locomotives, the daily mileage of

the locomotives is from 25 to 50 per cent. greater than the steam locomotives which they replaced, and their reliability is indicated by the fact that the delays chargeable to motive power are less than 50 per cent. as compared with steam motive power.

Experience has shown that the fuel cost with electric operation is from 40 to 75 per cent. of that with steam operation. There are no standby losses. Prof. Goss has estimated that one-fifth of the coal burned under locomotive boilers is burned while the locomotives are standing on sidings, or in starting fires.

The first cost of electrification is high as compared with the first cost of steam motive power. The cost of steam motive power for the average steam road is about $2,000 per mile of single track, while the cost of electric motive power runs from $7,000 to $12,000 per mile of single track. The cost of terminal electrifications may be even higher.

Power-house accident might put a whole railway system out of commission. The dependence of the electric locomotive on the power-house tends to make it inflexible in some respects.

Steam locomotives have passed through the development stages and are practically a standard product. They have developed to their present perfection through a period covering nearly a century. They are reliable and remarkably efficient, considering the conditions under which they operate, and their characteristics and limitations are well understood by a majority of the operating men. On the other hand, electric traction as applied to railway trains is scarcely two decades old. Progress in the electric arts has been so rapid during the past quarter of a century that apparatus which to-day represents best modern practice is likely to be on the scrap-heap tomorrow, not because it is worn out, but because it is obsolete.

Long-continued overloads overheat and burn out the electrical equipment. Such overloads are common in railway service and do not seriously injure a steam locomotive. If the overload on a steam locomotive is too great, it simply stops work, and no serious injury results.

As the rails are used as part of the main power circuit, the signal circuits for electric block signals and for interlocking plants are more complicated and expensive to maintain.

While no trainmen within the motor cars or locomotives have been killed or seriously injured, there have been a few fatalities among the men employed outside.

The losses, in a poorly-designed transmission and distribution may amount to as much as the power actually used to operate the trains.

In general it may be said that no one system of electric traction is best adapted to all classes of service. The direct current system seems best adapated to terminal work where a large number of trains are operated, and where, on account of the large number of stops per mile, rapid accelerations are necessary. On account of the denseness of the traffic the substations may economically be placed close together, and, as the distances are short, transmission losses are low. As far as fulfilling the general requirements of railway service is concerned, the series direct-current motor is the best motor available. But its use is limited because it cannot be operated at high voltages; low voltages on the trolley mean high line losses. Likewise, the alternating-current systems, with their high trolley voltages and low line losses, and motors which lack the powerful starting torque of the direct-current series motor, seem best adapted to long trunk-line service where the stops are few and the accelerating period is short as compared with the total time of the run.

Coast to Coast

Winnipeg, Man.—Excellent progress is reported upon the work of erection of the new Parliament buildings and court house at Winnipeg.

Brantford, Ont.—It is claimed that the C.P.R. will transform into an electrically operated road the new L.E. and N. Railway being constructed between Brantford and Lake Erie.

Owen Sound, Ont.—On August 1, plans for Owen Sound's drydock were filed with the Ottawa department of public works. The structure, which will be 775 feet long, will be the largest drydock on the Great Lakes.

Medicine Hat, Alta.—Several carloads of building materials have been delivered to the site of the Saskatchewan Bridge and Iron Company's factory; and the work of construction has started on the laying of brick and the erecting of the iron work.

Ottawa, Ont.—It is announced that the contract for the construction of the Morrisburg and Ottawa Electric Railway has been let; but further details concerning the contract will still be published. It is expected that the work on the line will commence very soon.

Revelstoke, B.C.—The automobile road which is being constructed to the summit in the Revelstoke national park is reaching completion. The work is starting at the upper end of the completed portion of the road, and 10 miles will be completed this summer at an estimated cost of $27,000.

Ottawa, Ont.—A flow of water of the highest quality was struck recently at Ottawa, while excavation was proceeding for the furnace room of the new horticultural building in the city's exhibition grounds; and it is believed that by the opening of the exhibition, a supply can be piped to all parts of the grounds.

Toronto, Ont.—The new registry office which is to be constructed in Toronto, is estimated to cost $400,000, and to be completed in 18 months. It is planned to be a 2-story structure with a basement, which is to contain a bindery in addition to regular equipment; and it will be as nearly fire-proof as possible.

West Vancouver, B.C.—The urgency of providing a water supply to West Vancouver is receiving the attention of the ratepayers and council of the municipality; and a report is to be made by the municipal engineer in the near future.

Quebec, Que.—About two weeks ago was commenced the work of setting in position the four shoes, upon which will rest the superstructure of the Quebec bridge, and which have been made by the St. Lawrence Bridge Company. Three cars were required to ship each shoe, and each has a weight of 204 tons and took 2 months to manufacture.

Brantford, Ont.—The hydro-electric branch line between Brant substation and Port Dover is to be commenced immediately. A new aluminum steel-covered cable has been completed by the commission between Brant substation and Dundas; and further protection is to be given to the city by the construction of a fourth series of cables from Niagara Falls to Dundas, according to a recent announcement made by the commission.

Fredericton, N.B.—Repairs are in progress on the road-bed of the Canada Eastern division of the I.C.R. New ties are being laid between Fredericton and Loggieville, and new sleepers are to be placed along the same portion of the line this month, as well as about 40 miles of 85-pound rails on different section of the same length of line. On the portion between Blackville and Derby Junction, 85-pound rails have already been installed.

Victoria, B.C.—Further delay in the progress of arrangements for the construction of the Johnson Street bridge structure has arisen owing to the request of the British Columbia Electric Railway Company to have modifications made in the plans for the bridge in order to widen it to 47 feet and to provide for the passage over the bridge of freight cars; and to have the bridge made stronger beneath so that heavy cars may be conveyed across it with safety.

Indian Bay, Man.—A recent inspection of the Falcon River diversion works at Indian Bay made under the auspices of the Greater Winnipeg Water District Commission shows that very rapid progress is being made. A distance of 1,500 yards has been built in the four weeks since the commencement of operations; while still more rapid work will now be done, since three engines, instead of two as previously will now be used for the hauling of sand and gravel.

Moose Jaw, Sask.—It is now expected that the necessary financial arrangements for the city's programme of sewer, watermain, sidewalk, and paving construction will soon be completed. And since no injunction has been served on the city by the Bitulithic and Contracting Company of Winnipeg to restrain the National Paving and Construction Company of Regina from proceeding with the paving for which it was awarded a contract in June, it is likely that the entire programme of works will be set in operation at once.

Victoria, B.C.—The contractors, Sir John Jackson, Limited, have erected another dolphin off Macaulay Point to replace their fifth dolphin which was carried away recently when a tug with a scow became entangled with the piles. It is expected that some time will elapse before this fifth breakwater dolphin, which marked the extreme end of the seawall, can be again placed in position. In the meantime the newly erected temporary dolphin will facilitate the dumping of rubble on the final 750-foot section of the breakwater.

Red Deer, Alta.—An announcement has been made which states that the Alberta Central Railway, a subsidiary line of the C.P.R. system, which extends for 60 miles from Red Deer to the Rocky Mountain House, will be taken over by the latter railway company at the conclusion of the present month, when a service will be placed in operation. All construction work on the line has been completed and all that at present delays the opening of the new branch is the lack of the consent of the board of railway commissioners, who have not yet made an inspection.

Barton Township, Wentworth County, Ont.—Some of the improvement work at present being carried out in Barton township includes concrete sidewalk construction approximating $16,000 and being undertaken by Chas. Brayley; while a staff of engineers is engaged upon plans for a comprehensive sewer and water scheme for the township, which, in the event of favorable consideration by both the township and city of Hamilton councils, will be constructed at a cost of $500,000. These plans, if possible, are to be completed and ready for submitting the first week of August.

Montreal, Que.—News comes from Montreal that the commission which was appointed to study the problem of the lowering of the water levels in the St. Lawrence River expects to hand in its report in time for action to be taken at the coming session of Parliament. The commission began its investigations last summer, and it is at present making examinations at Cap Rouge. It has been said that a system of weirs will be the possible recommendation to prevent the water from becoming shallower, these having been found satisfactory in other rivers.

Winnipeg, Man.—At the next session of the Greater Winnipeg Water District board, a deputation of Winnipeg business men will urge that still greater efforts be made to secure for Winnipeg a better supply of water considerably in advance of the contemplated time. It is believed that, with greater speed, the work can be completed within 3 years, rather than within 5 years' time. Business men of the city state that the water supply from the wells, though comparatively pure, is very hard and thus detrimental to the equipment of their establishments, causing them annually an enormous expenditure for the replacing of machinery.

Brandon, Man.—The city of Brandon is making every endeavor to hasten the completion of the construction of the G.T.P. Railway line into Brandon. To this end, a new matter which is to be brought before the Board of Railway Commissioners is with regard to a double subsidy which the railway company will receive in case the construction exceeds $15,000 per mile. A single subsidy of $32,000 per mile was provided in case that the construction work cost $15,000 or under; but if it exceeds $15,000 per mile, provision has now been made for a double subsidy, amounting to $64,000 per mile. Another new phase is that the company will be given an additional grant of 35 per cent. of the cost of the bridge, which will be required to be constructed to admit of the entry of the line into the city.

London, Ont.—The form of construction which will comprise the major portion of the work on the London breakwater provides for a 3-foot by 2-foot concrete base toe line and a 26-foot natural slope front of embankment, faced with reinforced concrete 11 inches thick at base and 7 inches thick on top of slope, where provision is made for a substantial concrete cap and a 5-foot sidewalk with guard tubular iron railing. Short lengths of vertical retaining walls will be necessary at the Oxford and Blackfriars bridge ends of the breakwater. The proposition is to provide for a top area of embankment, giving provision for a driveway, and utilizing existing conditions without disturbing trees or making excessive filling necessary in fixing face line of embankment. The estimated expenditure, as authorized, is $25,000.

London, Ont.—A report made following a recent inspection of the work being done on the London and Port Stanley Railway, shows that the new steel has been laid from St. Thomas to Port Stanley; and that new rails are being laid north of St. Thomas, this work on the whole line from London to the lake being practically completed. No statement of cost has yet been given on the roadbed, the 23 miles of steel rails, the 70,000 ties and the ballasting. A number of new sidings are to be constructed; and at present, the foundations of a new freight shed are being laid, which building it is expected to have completed by fall. The officials of the railway say that the road will be in operation within a few months, though so far no rolling stock has been purchased. However, they plan to lose no time in expending the $750,000 which has been expropriated for the electrification of the line.

Edmonton, Alta.—In addition to an offer of cheap power which has just been made to the city of Edmonton by New York and San Francisco engineers, it is understood that a second proposition is to be made by a syndicate, for which Sir John Jackson, of Montreal and London, Eng., is engineer. The site for the water power plant is just 50 miles from the city on the Saskatchewan River, above the Rocky Rapids. For two years or more, the company has been investigating and studying the location, and many plans have been prepared, showing where 3 immense storage dams can be built, capable of holding several hundred million cubic feet of water each. The scheme contemplates the development of 40,000 horsepower, while investigation has shown that further power can be secured when the load increases. The approximate expenditure, which the company estimates will be spent in harnessing the Saskatchewan River, is $6,000,000.

St. John, N.B.—Four hundred men, 5 tugboats, 3 dredges, 2 locomotives and trams and 4 reclamation plants are engaged upon the scheme of reclamation and development which is in progress on the western side of the St. John Harbor, where berths are being constructed to accommodate some of the large ocean steamships of the C.P.R. Company this coming winter, and where the contract is held by the Maritime Dredging and Construction Company, sublet to Cape and Company and to Mr. D. C. Clark. Three hundred workmen, 1 powerful suction dredge, 3 high-power elevator dredges, an ocean tug, 5 locomotives and ballast trains, 2 steam shovels, and other accessories, are being constantly employed by the Norton Griffiths Company in pushing forward the harbor and industrial development at East St. John. The firm has almost completed an immense breakwater of stone; has reclaimed over 12 acres of land for a ship repair plant; has excavated about one-third of the site for a dry dock; and has made considerable progress in dredging berths inside the breakwater for ocean commerce and in widening and deepening the entrance channel. Next spring the company will begin the construction of concrete and steel cylinder quays for ocean berths, and a pier at the entrance to the dry dock. The contract, which expires in 1917, covers the supplying of 23 steamship berths and involves an expenditure of over $30,000,000. It is expected that this particular point will be utilized by the G.T.P.R. Company.

Moose Jaw, Sask.—Recently, what was thought might prove to be a serious break occurred at the infiltration gallery at the headworks of the Moose Jaw water system at Caron, Sask. The break occurred while the water department was engaged at cleaning out one-half of the Rosedale reservoir, which has not been cleaned since put into commission in December, 1912. The break is a large one and only a few feet west of the pumping station, so that it does not allow of the water being brought in through the infiltration gallery. A large flume has had to be built out to the side of the natural reservoir and a steam pump installed. In this way the water now being used in the city is being pumped twice. In the first place, it is pumped from the reservoirs into the flume by the steam pump, and afterwards from the well into the pressure main to the reservoir. The cleaning of the reservoir has proven, apart from this, to be a difficult task, no provision having been made for the like at the time of its construction. One-half of the big reservoir, which has a capacity of 1,000,000 gallons, was left full, while the other half was emptied and Moose Jaw supplied with water direct from the pressure main from Caron. During the 18 months that the reservoir has been in use, there has been deposited in the bottom of it almost 4 feet of silt. This has been pumped into a surface reservoir which had to be constructed on a street north of the reservoir. The work has been in charge of Commissioner Mackie of Moose Jaw; and no further serious trouble is anticipated by him from the break at the headworks, provided none is caused by the steam pump before the break has been repaired.

PERSONAL.

J. B. NICHOLSON, B.A. Sc., is engineer for the Township of Barton, Ontario.

H. E. M. KENSIT, has tendered his resignation as city commissioner for the city of Prince Albert, Sask.

W. V. HUNT, electrical engineer in the employ of the British Columbia Electric Railway Company for the past several years, has resigned to engage in private practice in Vancouver, B.C.

OBITUARY.

The death has been reported from Porcupine, Ont., of Mr. B. C. Wolfram, manager of the West Dome mine.

It is reported that Mr. Louis Margolin, formerly with Clarke and Lyfrod, forest engineers, of Vancouver, met death recently in the Sierras, Nevada, by drowning. Mr. Margolin, who was 34 years of age, was a well-known timber estimator in British Columbia.

NEW CANADIAN MEMBERS A.W.W.A.

Among recent additions to the membership of the American Water Works Association are noted the following names:—

James Barr, M. E., Department of Water Works, city of Toronto.

R. C. Harris, Commissioner of Works, city of Toronto.

Robt. B. Owens, B.A., B.E., Governmet Buildings, Edmonton.

Joseph Race, City Bacteriologist and Chemist, Ottawa.

R. A. Ross, Consulting Engineer, Montreal.

Jas. T. Wickham, City Engineer's Office, Eastern Division, Montreal.

JOINT ROAD CONGRESS IN 1915.

The matter of holding a joint convention or congress in which the American Highway Association and the American Road Builders' Association are the chief factors, is under consideration in connection with the Panama Pacific Exposition in 1915. The meeting will probably be held at Oakland or San Francisco.

COMING MEETINGS.

WESTERN CANADA IRRIGATION ASSOCIATION.—Eighth Annual Meeting to be held at Penticton, B.C., on August 17, 18 and 19. Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

AMERICAN PEAT SOCIETY.—Eight Annual Meeting will be held in Duluth, Minn., on August 20th, 21st and 22nd, 1914. Secretary-Treasurer, Julius Bordollo, 17 Battery Place, New York, N.Y.

CANADIAN FORESTRY ASSOCIATION.—Annual Convention to be held in Halifax, N.S., September 1st to 4th, 1914. Secretary, James Lawler, Journal Building, Ottawa.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown, Indianapolis, Ind., Secretary.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.—11th Annual Convention; 5th American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau St., New York, N.Y.

Volume 27. Toronto, August 13, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

STORAGE ON THE UPPER ST. MAURICE RIVER

PROPOSED MASONRY DAM AND STORAGE WORKS NEAR LA LOUTRE FALLS FOR THE REGULATION OF RIVER FLOW—TO BE ERECTED UNDER EXTREME CONDITIONS OF TRANSPORTATION AND CLIMATE.

A DIFFICULT storage undertaking, but one that will have an important bearing upon power development and the lumbering industry in northern Quebec, is under construction. The consideration of flow regulation of this river was adopted by the Provincial Legislature in 1912, and an act was passed granting additional powers to the Quebec Streams Commission for the execution of the works provided for. Since that time, the engineers of the commission have gathered all available data concerning precipitation, run-off and evaporation on the watershed, as well as the stream flow of the river and its tributaries. This information was, generally speaking, too meagre to be of much value, necessitating the establishment of gauging stations all along the river, as well as other careful data compilation.

Records of daily observation at Shawinigan from 1900 to 1912 had shown that the minimum flow of the river was 6,000 cu. ft. per sec., representing 0.37 cu. ft. per sec. for every square mile of drainage basin. The proportion of the flood to the minimum flow on the St. Maurice is, generally speaking, 30 to 1. The commission, after careful study, ascertained that, by a storage dam above the La Loutre rapids a volume of water estimated at 160 billion cu. ft. could be stored. The flow thereof could be made as follows:

For 150 days	....	12,345 cu. ft. per sec.
" 200 "	....	9,317 " "
" 250 "	....	7,407 " "
" 300 "	....	6,172 " "

The present storage reservoirs on the Manouan River, a tributary of the St. Maurice, give a total storage of 590 square-mile-feet, or 16,448,256,000 cubic feet, equal to a flow of:

For 150 days	....	1,269 cu. ft. per sec.
" 200 "	....	952 " "
" 250 "	....	761 " "
" 300 "	....	635 " "

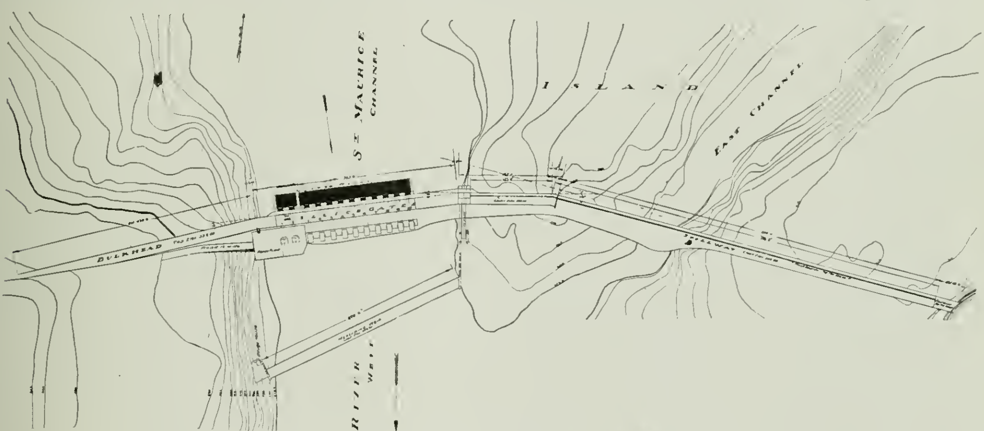


Fig. 1.—Plan of the Proposed Dam on the St. Maurice River.

But a close analysis of the records giving the flow at Shawinigan shows that, for the year 1906, the lowest year for the period from 1900 to 1912, it was as follows:

Under 12,000 c. f. s.	—230 days	—Average	8,000 c. f. s.
" 15,000 c. f. s.	255 "	"	8,558 c. f. s.
" 18,000 c. f. s.	270 "	"	9,030 c. f. s

The records for 1911 show practically the same conditions. To regulate the flow to 12,000 cubic feet per second would have required an average of 4,000 cubic feet per second for 230 days. The storage of the two reservoirs will give, for the same period, 8,051 and 828 cubic feet per second respectively, leaving in the reservoirs 4,879 cubic feet per second, or 55% of the water stored.

The regulating of the flow to 15,000 cubic feet per second would, in the same year, have required an average of 6,442 cubic feet per second during 255 days. The two storage reservoirs could give for that length of time 7,262 and 746 cubic feet per second respectively, leaving 1,566 cubic feet per second, or 19½% stored water not needed.

The regulating of the flow to 18,000 c. f. s. would have required an average of 9,000 c. f. s. for 270 days. During that period the reservoirs would only give 6,859 and 705 c. f. s. respectively, say, a deficiency of 1,437 c. f. s. The river could not be regulated to that high figure in a year when the rainfall is very low.

The river could, however, be regulated at 15,000 c. f. s. at Shawinigan, leaving an over-supply of the stored water in a very low year. But the commission deem it advisable to provide for the loss in the volume of water from the storage reservoirs, especially in winter, while coming down the distance of 220 miles to Shawinigan. And the fact also is not overlooked that water may be needed for floating logs at a time when it would not be wanted for power purposes.

For these reasons the commission adopted a flow of 12,000 c. f. s. to compute the increased value of the water powers concerned. A scheme was accordingly worked out, as outlined below, for storage above La Loutre falls.

It should be remembered that at present 206,300 h.p. are being developed on the river; viz., Shawinigan 163,000; Grand'Mère, 19,500; La Tuque, 3,500. In addition, the Shawinigan Power Company is adding two units of a capacity of 37,000 h.p., while the plant of the Laurentide Company at Grand'Mère is being added to, increasing the capacity of the plant to 120,000 h.p.

The present and future value (after regulation) of the water powers of the St. Maurice River are indicated in Table I.

The site of the proposed dam across the St. Maurice, 2⅓ miles above the falls of La Loutre, is 120 miles from Escalona, 37 miles in a straight line north of Parent, a divisional point on the Transcontinental Railway, and 240 miles from the St. Lawrence, following the course of the river.

In its preliminary laying out, bench marks were established on all important lakes and at all falls. Two different level lines were run with the same instrument, one checking the other by means of the height of the instrument. A party under Mr. W. Thibaudeau, assistant engineer, starting from Escalona on the Transcontinental, proceeding to the site of the dam and from there by way of Manouan, back to the Transcontinental, completed the circuit of 180 miles. The allowable error was not to exceed 0.05 d where d was the distance in miles. The results obtained were found considerably less in error than that amount. These levels checked figures previously obtained respecting the elevation of various lakes forming part of the drainage basin whose waters it is proposed to store. Some 35 bench marks were established at the falls and on the various lakes during 1913.

Another party proceeded to the site of the dam to investigate the nature of the ground. Its borings were made with the use of a McKiernan-Terry core-drill mounted on a raft 20 ft. x 20 ft. and moored by cables and pulleys to a steel cable across the river. Each boring was located by triangulation and was carried down to a depth of 12 ft. to 15 ft. They were made at 20 points in the western and 8 points in the eastern channel of the river, the total length of rock examined being 323 linear ft.

Gaugings were recorded at La Loutre to supplement those available at Shawinigan, 220 miles distant. The flow of the river was measured by determining the velocity and the cross-section, the velocity being measured by a Gurley current meter. The average velocity was determined at 3 points; viz., 0.2, 0.6 and 0.8 of the depth as per the method commonly used. The maximum flow was observed to be 14,500 cu. ft. per sec. and the minimum

Table I.—Statement of the Water-powers on the St. Maurice River.

NAMES.	Distance from St. Lawrence, (miles).	Head in feet.	Approximate area of drainage basin above (sq. miles).	Actual minimum flow, 0.37 cu. ft. per sec. per sq. mile.	Present value 80% efficiency.	Regulated minimum flow of 12,000 c.f.s. at Shawinigan.	Value after regulation.	Increase in value through regulation.	Power installed.	Increased primary power which will be used.	Increased power left unused.	Increased water-power yet unsold.	Present owner.
	Miles.	Ft.	Sq. M.	c. f. sec.	H.P.	c. f. sec.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	
La Gabelle	13	10	16,550	6,123	5,556	19,123	11,010	5,454	.....	.....	5,454	.....	Grès Falls
Les Grès	15.5	40	16,500	6,105	22,200	12,105	44,018	21,818	.....	.....	21,818	.....	" "
Shawinigan ..	21	150	16,200	6,000	81,818	12,000	163,636	81,818	183,300	81,818	.....	.....	Shawinigan W. & P. Co.
Grand'Mère ..	33	75	15,800	5,870	40,022	11,870	80,931	40,909	19,500	40,909	.....	.....	Laurentide Co.
La Tuque ...	103	80	12,000	4,440	32,291	10,440	75,927	43,636	3,500	.....	43,636	.....	Q.&St.Maurice Industrial Co.
Sans Nom	110	128	10,030	3,711	4,318	9,711	11,300	6,982	.....	.....	.....	6,982	Crown.
Vermillon	119	16	10,020	3,707	6,066	9,707	15,884	9,818	.....	.....	.....	9,818	"
Blancs	138	136	8,115	3,002	37,115	9,002	111,296	74,181	.....	.....	.....	74,181	"
Grands-Cœurs .	171	90	6,425	2,377	19,448	8,377	68,539	49,091	.....	.....	.....	49,091	"
La Grâce	183	33	6,325	2,340	7,020	8,340	25,020	18,000	.....	.....	.....	18,000	"
De L'Ile	191	44	6,225	2,303	9,212	8,303	33,212	24,000	.....	.....	.....	24,000	"
									206,300	122,727	70,908	182,072	

flow 3,500 cu. ft. per sec. While the proportion between flood water and low water at Shawinigan was 27 to 1, at La Loutre it was found to be 4.6 to 1.

Excavation revealed the existence of from 6 ft. to 8 ft. of sand on the west side of the site, quite suitable for concrete. Test pits 8 ft. square were dug at various points, revealing a mixture of sand and stones overlying rock within a depth of from 6 in. to 16 ft. of the surface. Several of the pits had to be abandoned owing to the excessive seepage.

vestigated with the result that "Stoney" sluices, or those of a similar type, were considered the most suitable. Five different dam sections, of dimensions larger than usual, were investigated in regard to their stability under extremely severe assumptions of forces acting on the dam, these sections being, plain gravity section with vertical, also sloping, upstream face, hollow dam with deck at an angle of 45°, the same type with upper part of deck at 30° and lower part at 60° to the horizontal, and rock-fill dam with concrete shell. About 700 ft. of the dam is to

Fig. 2.—Western and Eastern Channels at the Site of the Dam.

The plans for the dam were prepared by Mr. J. W. Thurso, hydraulic engineer. Mr. Edw. Wegmann, of New York, was retained as consulting engineer. The dam, shown herewith in plan and elevation, will be about 1,720 ft. in length and will follow a broken line formed by four straight lines intersecting at obtuse angles. The crest of the dam will be at an elevation of 1,335 ft. above sea level, while that of the overflow weir will be 10 ft. lower. The plan comprises a sluiceway for logs and floating rubbish, 10 gates, each 7½ ft. by 12 ft., capable of discharging 18,000 cu. ft. of water per sec., a rein-

form the overflow weir, its top being, as stated, 10 ft. below the crest of the remaining part of the dam. The maximum height will be 80 ft. above the foundation. The rock is Laurentian gneiss lying near the surface, rough from erosion, but entirely free from seams and fissures. It is an extremely hard stone, well adapted for the foundation and masonry of the dam.

It is proposed to unwater the river bed at the site of the proposed dam to permit of the necessary cleaning of the bed rock surface, the cutting of channels or checks for bending, etc. This will require the construction of

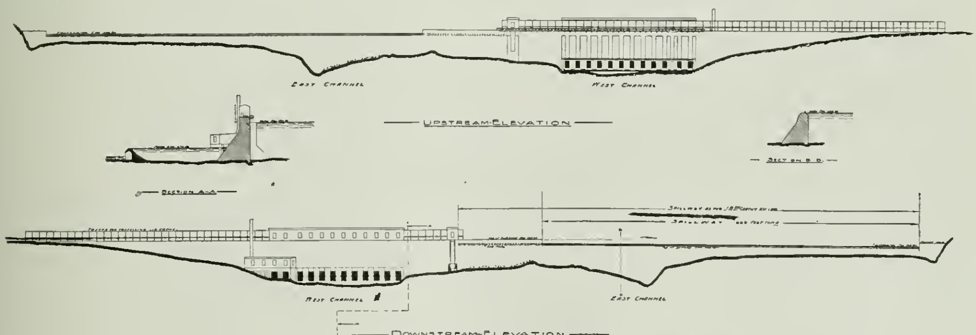


Fig. 3.—Elevations and Sections of the Proposed Dam.

forced concrete measuring weir 375 ft. in length with abutments and wing walls. In addition, the development will include a power house, two gate houses, a gauge-house, a 12-ft. roadway and a telephone line from Manouan. These will be described in a later article.

Five different types of dams were investigated in regard to their adaptability for the proposed work, these types being plain gravity dam with buttresses acting as ice breakers, hollow ram with both reinforced and arched deck, retaining wall type with loaded upstream footing, and timber dam. Different types of gates were also in-

cofferdams and the installation of pumping appliances. The surfaces of the rock foundations are to be sufficiently roughened to bond well with the masonry and cut to rough benches or steps.

The concrete for the body of the dam will be of 1:2½:5 mix, Portland cement, natural sand and broken stone respectively. Stones, varying in size up to 4 cu. yds., will be embedded in the concrete after thorough cleaning, placed 6 to 8 inches apart to allow thorough concreting between them. Reinforcement used is to be of square twisted bars, of extra soft open-hearth steel.

The site, though well adapted for a strong, watertight masonry dam, has the disadvantages of severity of

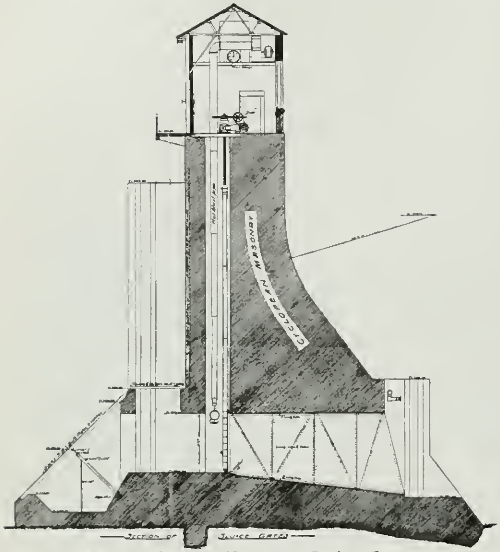


Fig. 4.—Section Through Sluice Gates.

winter weather, requiring extra strength to resist ice pressure, and inaccessibility, which will add materially to the cost of construction.

The plans have been prepared, and the work will be executed under the direction of the Quebec Streams Commission, of which Olivier Lefebvre, C.E., is chief engineer, and Ernest Bélanger, C.E., and Wm. I. Bishop, C.E., are commissioners. John W. Thurso is designing engineer of the dam, and Edward Wegmann and J. M. McCarthy consulting engineers.

In his report, Mr. Wegmann commented as follows on the design of masonry dams in general, and upon the application to the St. Maurice storage project:

Theory of Masonry Dams.—The construction of masonry dams dates from the latter part of the sixteenth century, when a number of high masonry reservoir walls were built in the southern part of Spain to store water for irrigation. The oldest of these structures is the famous Almanza dam, 68 feet high, which, according to some old records, was in existence prior to 1586. In the beginning of the nineteenth century a number of masonry dams, 30 to 75 feet high, were built in France in connection with the construction of canals. None of the early masonry dams were built according to correct principles. It has been shown that some of these reservoir walls would be stronger if they could be turned around, so that their upstream faces would be downstream.

The French engineer, M. de Sazilly, was the first to point out, in 1853, the correct principles upon which the design of the profile of a dam should be based. He was followed in the study of this subject by Delocre, Bouvier, Pelletreau, Lévy, etc., in France, and by Prof. Rankine, in England. According to these engineers there are three ways in which a masonry dam can fail; viz., by overturning; by sliding or shearing apart, or by the masonry or the foundation being crushed by the pressure it has to sustain. To insure safety, an ample factor of safety must

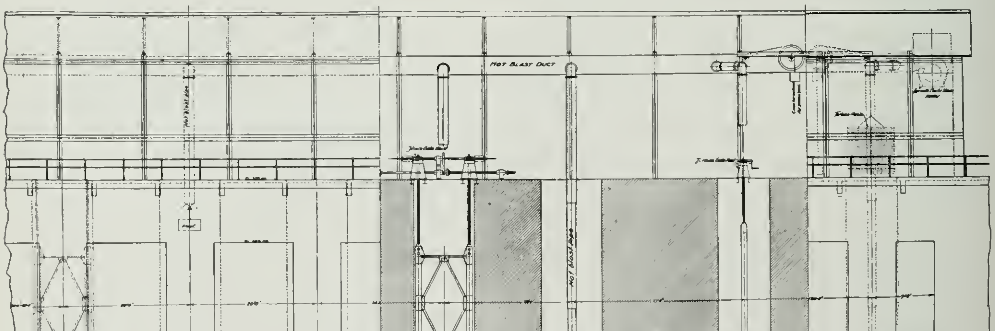
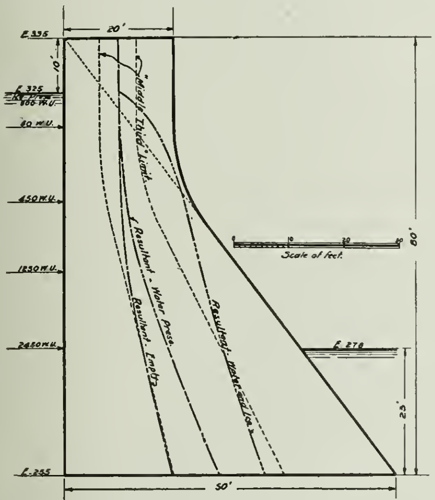


Fig. 5.—Part Longitudinal Section of the Dam.

be provided against each of these possible manners of failure.

A number of high masonry dams have been built in France and Algeria according to the principles proposed by the engineers mentioned above. The greatest of these works is the celebrated Furence dam, built in 1862-66 near St. Etienne, France. It is about 170 feet high, and was for many years the greatest work of its kind.



NOTE: 50 W.U. = 50 Water Units = 50×62.5 lbs.

Fig. 6.—Profile Which Accompanied the Consulting Engineer's Report.

Prior to 1884 there was only one high masonry dam in America, viz., the Boyd's Corner dam, 78 feet high, which was built in 1866-72 to form a storage reservoir for the city of New York. From 1888 to the present time a number of high masonry dams have been built in various parts of the world. The greatest of these works with their principal dimensions are given in Table II.

Up to about twelve years ago, the profiles for all masonry dams, with one exception, were determined by considering the water as acting only on the upstream faces of the dams. The failures of three dams built on poor, porous rock, viz.: the Bouzey dam in France in 1895; the Austin dam in Texas in 1900, and the dam at Austin, Pennsylvania, in 1911, drew the attention of engineers to the fact that water might percolate under the base of a dam and exert a strong upward pressure, which would diminish the strength of the dam materially. This led designers to include such an upward force in determining the profile of a masonry dam. The intensity of the uplift depends evidently on the permeability of the rock. It may vary from practically nothing in good sound rock to almost the full head of the reservoir in porous rock, full of seams. The pressure of the water against the upstream face of a dam is easily calculated, but the amount of a possible upward force under the base or in the masonry itself must be decided, of necessity, by the judgment of the designer.

In addition to the action of the water against the upstream face, and possibly, under the base of a dam, we must consider in northern latitudes the thrust which ice may exert against a dam in forming and in expanding during a rise of temperature. When confined, as between two bridge piers, thick ice exerts a great force in expanding. A small masonry dam at Minneapolis, Minnesota, was partly revolved in 1899 by a sheet of ice, 4 feet thick and 300 feet long, lying between the dam and the retaining wall of a canal. The dam was 18 feet high, 5.25 feet wide at the top, and 12 feet at the base. The top of the wall was forced nearly a foot out of line, but, when the ice was cut, the wall returned nearly to its original position. If the ice is only about 12 to 15 inches thick and forms a long sheet, it will buckle and form "reefs" and possibly may not cause a great pressure against a dam. In the present state of knowledge we cannot determine accurately the pressure which ice may exert against a dam, and the allowance to be made for this force in designing the profile of a dam is a matter of judgment which must be based upon the local conditions. The following reservoir walls have been built for the city of New York without making any allowance for ice pressure or any possible upward pressure under the base, and stand successfully without the slightest indication of any weakness, viz.: The Sodom dam, 98 feet high, built in 1888-93; the Titicus dam, 135 feet high, built in 1890-95; and the new Croton dam, 297 feet high, built in 1892 to 1907.

On the other hand, engineers have deemed it advisable of late, to take ice pressure and possible uplift under the dam into account in designing the profile, as will be seen in the following table:

Recent Masonry Dams.

Dam.	Built.	Height, ft.	Ice pressure, lbs. per lin. foot.	Uplift.
Wachusett, Mass. ..	1900-06	228	47.000	
Cross River, N.Y...	1905-09	170	24.000	
Croton Falls, N.Y...	1906-11	173	30.000	
Olive Bridge, N.Y...	1907-13	252	47.000	
Kensico, N.Y.	In construction.			

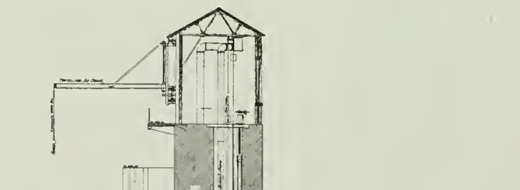


Fig. 7.—Cross-section of Portion of Power House, Showing Turbine Inlet.

In all of the above dams, the upward pressure under the base of the dam was taken as ⅔ of the full head in the reservoir at the upstream side, diminishing to zero at the downstream side.

As to recommendations for the design of the dam across the St. Maurice River, there are two types of construction that might be adopted. The dam might be built

as a solid masonry dam, or as a hollow dam of reinforced concrete. It is recommended that it be built as a solid dam of cyclopean masonry, consisting of large blocks of stone laid in and surrounded by Portland cement concrete.

As regards the profile to be adopted, this depends upon the weight of the masonry, about which we have thus far no accurate data. The specific gravity of the stone should be accurately determined, and then the percentage of large stone in the cyclopean masonry must be estimated to find the probable average weight of the masonry. In the part of the New Croton dam which was built of cyclopean masonry, there were 40 per cent. of large stone in the foundation and 20 per cent. near the top, the average being 23 per cent. of large stone for the whole wall. In the St. Maurice River dam, which will be only 80 feet high, the percentage of large stone will be less, probably not over 20 per cent.

It is recommended that an ice pressure of 50,000 lbs. per linear foot, acting at the level of the crest of the overflow weir, be assumed.

With the solid formation of rock upon which the dam is to be built there will not be much upward pressure,

Table II.—High Masonry Dams.

(Dimensions in feet)

Dam and location.	Date of construction.	Depth of water.	Height above bed-rock.	—Width— Top.	Base.	Length on crest.	Plan.
Alicante (Spain)	1579-1594	127	135	65.6	110.6	190	Curved.
Puentes* (Spain)	1785-1791	154	164	35.7	144.3	925	Polygonal.
Val de Infierno (Spain)	1785-1791	...	116	42.1	137.0	330	"
Zola (France)	About 1843	120	123	19.0	41.8	205	Curved.
Lozoya ((Spain)	1852	94	105	22.0	128.0	238	Straight.
Furens (France)	1862-1868	164	171	9.9	161.0	328	Curved.
Terhay (France)	1865-1868	113	125	13.1	81.7	...	"
Habra** (Algiers)	1865-1873	117	125	14.1	95.0	1476	Straight.
Ban (France)	1867-1870	138	157	16.4	127.0	...	Curved.
Gileppe (Belgium)	1869-1875	148	154	49.2	216.5	771	"
Villar (Spain)	1870-1878	162	170	14.8	154.5	546	"
Pas du Riot (France)	1872-1878	...	113	....	.....	...	"
Poona (India)	....	...	108	13.8	60.8	5136	Polygonal.
Hijar (Spain)	1880	...	141	16.4	147.0	236	Curved.
Gorzente (Italy)	1880-1883	121	126	13.1	99.6	492	"
Lagolungo (Italy)	About 1883	...	144	16.4	.....	...	
Gran Cheurfas (Algiers)	1882-1884	...	131	13.1	134.5	509	Straight.
Hamiz (Algiers)	1885	115	135	16.4	91.2	532	"
Vyrnwy (England)	1882-1889	...	146	20.0	117.8	1350	"
Tansa (India)	1886-1891	...	118	12.0	100.0	8800	
San Mateo (United States)	1887-1889	...	170	20.0	176.0	700	Curved.
Tache (France)	1888-1892	...	161	13.1	.....	...	"
Bhatgur (India)	....	...	130	12.0	74.0	4067	
Beetaloo (India)	1888-1890	...	110	14.0	110.0	580	Curved.
Periar (India)	1888-1897	...	180	12.0	136.0	1200	Straight.
Mouche (France)	About 1890	95	101	11.5	.....	1346	"
Lagrange (United States)	1890	...	125	24.0	90.0	320	Curved.
Titicus (United States)	1890-1895	...	135	18.0	75.0	534	Straight.
Hemmet (United States)	1891-1895	...	136	10.0	100.0	...	Curved.
Butte City (United States)	1892	...	120	10.0	83.0	350	"
New Croton (United States)	1892-1907	150	297	22.0	206.0	2168	Straight.
Echapre (France)	1894-1898	116	121	17.0	88.6	541	Curved.
Cotatay (France)	1900-1904	121	144	16.2	.....	509	"
Lake Cheesman (United States)	1900-1904	...	232	18.0	176.0	...	"
Spier Falls (United States)	1900-1905	80	154	....	.....	1369	Straight.
Boonton (United States)	1900-1905	105	114	17.0	77.0	2150	"
Wachusett (United States)	1900-1906	...	228	25.8	187.0	1476	"
Ondenon (France)	1901-1904	107	123	15.4	93.8	420	Curved.
Urft (Germany)	1901-1904	...	190	18.0	165.7	1037	"
Komotau (Austria)	1901-1904	...	139	13.1	98.4	509	"
Cher (France)	About 1907	...	154	15.4	141.1	323	"
Cataract (Australia)	1902-1908	150	192	16.5	158.0	811	Straight.
Roosevelt (United States)	1905-1911	240	280	16.0	170.0	1080	Curved.
Pathfinder (United States)	1905-1910	...	206	10.0	94.0	425	"
Shoshone (United States)	1905-1910	...	324	10.0	108.0	200	"
Cross River (United States)	1905-1909	106	170	23.0	116.3	772	Straight.
Croton Falls (United States)	1906-1911	97	173	23.0	127.7	1100	"
Olive Bridge (United States)	In construction	210	252	26.33	200.0	1000	"
Assuan Dam (Egypt)	Raised, 1907-1911	82	112	36.0	.....	6200	"

* The Puentes Dam was ruptured in April, 30, 1802.

** The Habra Dam failed in December, 1881.

providing, of course, that the masonry is well laid in Portland cement mortar, the concrete being generally mixed in the proportion of 1 :2 :4.

The design of the profile submitted is based on the dam's being subjected only to the hydrostatic pressure of the water, acting on its upstream face, and also, to the ice pressure mentioned above. With these forces acting upon the dam, the profile is considered safe although, theoretically, the line of pressure would fall outside of the middle third limit for part of the height of the dam. A similar condition exists in some of the dams built for the city of New York, but these structures stand, nevertheless, successfully. In these dams the margin of safety is greater near the bottom than at the top, which is a good condition.

Having determined the profile in this manner, the effect of the greatest conceivable upward pressure acting on the dam has been calculated. Even in this case the lines of pressure would be kept within the profile of the dam. Some tension would be caused in the masonry, but such an extreme case of upward pressure can never occur and even if it did, the dam would still stand, owing to the cohesion of the masonry.

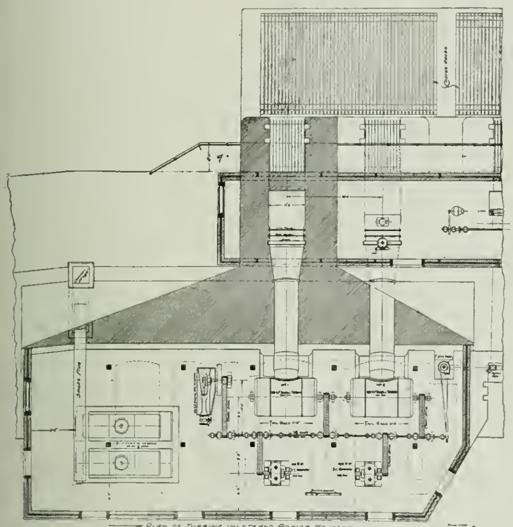


Fig. 8.—Plan of Proposed Power House.

The width given to the top of a dam must be sufficient to enable the wall to resist shocks from waves and floating bodies and also ice pressure. On account of the thickness of the ice that will form in the proposed reservoir, it is recommended that the dam be made 20 feet wide at the crest. Theoretically this would not be enough to enable the upper part of the dam to resist the combined thrust of the ice and water by its weight alone. The cohesion of the masonry would have to be counted on to insure the stability of the upper part of the dam. From practical examples a width of 20 feet at the crest is felt to be sufficient.

At the top of the overflow weir, however, some reinforcement with steel bars will be required, as this part of the dam has not the weight of masonry, 20 feet wide and 10 feet thick, above the assumed ice line to add to its strength.

THE DEVELOPMENT OF ELECTRIC TRACTION.

By John R. Hewett in "General Electric Review."

THE steam railroad is just about a century old and the electric railway about a quarter as old, and when we think of the astounding developments that have taken place in this comparatively short space of time, we can hardly refrain from asking ourselves why this development has come about. The answer to this question would seem to be that the civilization of the world is absolutely dependent upon rapid communication between man and man—the communication of thoughts and of material matter. The invention of the steam engine and locomotive pointed the way, and then, with the introduction of the electric telegraph and the submarine cable, the different peoples of the world became so much more closely connected in thought that the general extension of a more rapid means of physical communication seemed imperative. The stage coach on land and the sailing ships on the seas had to be replaced by quicker methods of communication. It was about the beginning of the nineteenth century that people began to recognize that the country which developed the best means of rapid communication with other countries would be the leader in the commerce of the world—those that had most ships would control the seas and the markets of the world; and, similarly, that it was only those countries that developed an efficient system of land transportation that could develop their natural resources, and, consequently, become manufacturing countries.

The recognition of these great economic truths came about just at a time when the whole world had been well nigh torn asunder and rent by a series of wasteful and disastrous wars. In looking back at the history of this period, the development seems miraculous. All sections of the civilized world would seem to have taken on a new form of life, and commerce became to be recognized as a better trade than war. The development of better means of communication aided the rapid spread of civilization, and the spread of civilization stimulated industrial developments of all kinds. Thus was started an action and a reaction which has been continued up to the present time, with the result that to-day a man living in New York knows more about the capitals of China and Japan than his grandfather knew about many towns scarcely a hundred miles from his own door, and that each of us individually to-day are virtually in connection with the whole rest of the world. It is easier to make a trip around the entire globe to-day, in comfort and in luxury, than it was to travel from one end of New York State to the other, at the cost of hardships and dangers, a hundred years ago.

These developments have absolutely changed our modes of living, and during the transition stage one thing of vital importance has happened, viz., we have let these means of communication become our masters as well as our servants. When we stop to consider the enormous populations congested into our large cities, and the distances from which their daily food supplies have to be transporated, it is apparent that our means of communication are the masters of the situation. Should they for any reason fail to fulfill their functions in the community for even a brief time, it would spell death by starvation to hundreds and thousands of human beings.

So in this brief period of one century we have built up a set of conditions that has so complicated our modes of living and increased our dependence on the labors of others, living at a great distance from us, that now our transportation facilities have become just as much one of the necessities of life as are food and clothing. The

character of our transportation systems has thus become a matter of national importance.

It was long after this civilizing movement had set in and became well established that the electric railway made its appearance. In fact, it is just about twenty-five years ago that Sprague, Van Depoele, Daft and Bentley-Knight, amongst other energetic pioneers in the industry in this country, began to show the possibilities of this new mode of traction. In this short space of time electric traction has not only become well established, but has grown to be one of the most important industries in the country. In the last twenty-five years electric traction has, practically speaking, superseded all modes of transportation for city, suburban and interurban service, including elevated railways and subways. A whole paper could be written with profit to show the advances that have been brought about in our social status by the electric railway. There are few who realize how much the public, and especially those interested in real estate, have benefited by the enterprise of those who have been responsible for the building of our electric railway systems, but we have not time to go into this phase of the subject here.

It seems to-day that the field for electric traction is as broad as the traction field—that is to say, that it has been developed to a stage where there are no longer any technical limitations to its adoption on every railroad in the country. The traffic could be handled electrically and the considerations which govern the choice between steam and electric traction are financial and economic, not technical. Within the last decade we have seen many notable examples of the electrification of steam railroads, and, judging by the general interest that has been awakened in railroad circles and the recognition of the splendid service being performed by those electric installations already made and the economies secured by their adoption, we shall see many more examples of steam railroads adopting electric traction during the next decade.

All modes of traction depend primarily upon energy, and whether steam or electric traction ultimately becomes universal depends upon the relative economic values of the form of energy used. It should be noted here that of all the forms of energy available, only two are generally considered for traction purposes, viz., the chemical energy stored in coal and electric energy. Dr. Steinmetz in a paper before the Franklin Institute has recently pointed out the reason for this, viz., because they are the only two forms of energy that can be economically transported or transmitted over long distances. The two following paragraphs are taken from Dr. Steinmetz's recent paper:—

"Electrical energy can be transported, or, as we usually call it, transmitted—economically over practically any distance. Mechanical energy can be transmitted over a limited distance only, by belt or rope-drive, by compressed air, etc.; heat energy may be carried from a central steam-heating plant for some hundred feet with moderate efficiency, but there are only two forms of energy which can be transmitted over practically any distance, that is, which in the distance of transmission are limited only by the economical consideration of a source of energy nearer at hand—electrical energy, and the chemical energy of fuel. These two forms of energy thus are the only competitors whenever energy is required at a place distant from any of Nature's stores of energy. Thus, when in the study of a problem of electric power transmission we consider whether it is more economical to transmit power electrically from the water power or the coal mine, or generate the power by a steam plant at the place of demand, both really are transmission problems, and the question is whether it is more economical to carry energy electrically over the transmission line, or to carry it chemically, as coal by the railroad train or boat, from the source of energy supply to the place of energy demand, where the energy is converted into the form required, as into mechanical energy by the electric motor or by steam boiler and engine or turbine.

"Electrical energy and chemical energy both share the simplicity and economy of transmission or transportation, but electric energy is vastly superior in the ease, simplicity, and efficiency of conversion into any other form of energy, while the conversion of the chemical energy of fuel into other forms of energy is difficult, requiring complicated plants and skilled attendants, and is so limited in efficiency as to make the chemical energy of fuel unavailable for all but very restricted uses: heating and the big, high-power steam plant. To appreciate the complexity of the conversion of the chemical energy of fuel, compared with the simplicity of electrical energy conversion, imagine the domestic fan motor with coal as source of energy: a small steam engine, with boiler and furnace, attached to the fan: to start the fan, we have to make a coal fire and raise steam to drive the engine. This illustrates how utterly unavailable the chemical energy of fuel is for general energy distribution. Generally, energy distribution, therefore, may justly be said to date from the introduction of electric power."

From the foregoing it will be seen that electrical energy and the chemical energy stored in coal are the only two available sources of energy for traction purposes, and that in the case of coal we have to carry our fuel and generating apparatus, adding enormously to the weight of the moving element, and consequently to the cost of transportation, while in the case of electrical energy, there is no fuel or generating apparatus to be transported. This gives electric transportation a tremendous advantage, but at the same time it must be remembered that in the case of electric traction we have to provide the means for supplying the moving elements with a continual supply of energy, which means the construction of a trolley system or third rail for the whole length of the line.

The general extension of hydro-electric developments, which is fast covering the country with a network of high-tension transmission lines, is making a source of cheap energy available in many localities. This development will prove quite an asset to many roads who would rather buy than manufacture their own power.

In the case of electric traction, the range of energy supply is very flexible—we have the whole resources of the power house available—while steam traction, if we want excessive power for only a short distance we have to transport sufficient generating apparatus and fuel all the time we are working at light loads.

So the question of the electrification of steam railroads resolves itself to a question of whether it is cheaper to build a system for the distribution of energy for the whole length of the line than to carry the fuel and generating apparatus along with our freight and passenger trains.

This is absolutely a question of economies, and will be settled as such in each individual case after a careful analysis has been made of the individual requirements.

If the traffic were sufficiently dense, it would always pay to electrify a railroad, because the economies to be secured by electric operation would more than offset the interest to be paid on the initial expenditure, but where the traffic is scarce and the length of the line is long, that is to say, where the initial cost of electrification and the cost of operating and maintaining permanently an ex-

tensive system of energy distribution would be great, in comparison with the cost of hauling the fuel and generating apparatus along with the train, then steam traction is still the most economical.

We have many examples of steam railroads with dense traffic that have made or are contemplating the change from steam to electric traction to secure these economies, and also many special cases where electrification has come into being to secure some special economies or overcome some special conditions, such as the abatement of smoke in terminal stations, etc.

The analysis of operating conditions to determine whether it would be economical to electrify or to continue steam operation is becoming an important branch of the engineering profession. There are to-day many instances where electrification would pay, but where difficulty would be found in financing the undertaking. When some of the roads that are contemplating electrification have done so and have gained the experience from actual practice, it is likely that other roads will follow their example and that the electrification of our steam railroads will become one of the large electrical industries of the country.

When an analysis of the conditions in any particular instance has shown that electrification would be economical, we still have to determine which of the available systems of electrification is best suited to the requirements. This is purely a question of economics, and here again is the necessity for a careful analysis to determine the most economical way of distributing the expenditures to be made in the inital construction, the operation and the maintenance of the system.

For example, when the traffic is very dense, and where cars or trains of moderate size have to be run at very frequent intervals and the total energy used at any one instant is not very greatly in excess of the average load, then standard 600-volt apparatus has no equal. There is no objection to the heavy outlay in substation apparatus and feeder copper when such apparatus will be in operation at an efficient load factor for a good percentage of the twenty-four hours.

It is when the load is such that the cost of copper and of the machinery installed in the power house and substations is excessive, and the percentage of time that they will be working at anything like an efficient load factor is small, that we look about for ways and means of reducing the amount of machinery necessary and of increasing the time that it will be in actual use. As a matter of fact, these conditions are just what exist on most systems where electrification is contemplated, and it is to meet such conditions and make electrification an economic possibility that the high-voltage systems, viz., the three-phase system, the single-phase alternating current system and the 1,200 and 2,400 -volt direct current systems have been evolved; in other words, higher voltage is an economic necessity to avoid excessive expenditure in copper and in machinery which would only be working at part or no load for a great percentage of the working day.

The three-phase system has found but little favor up to the present in this country, while it has been very extensively adopted in Europe; but there is one case, viz., the electrification of the Cascade Division of the Great Northern Railway, where such a system has been in successful operation for some years in this country. It would seem in the light of our present knowledge that such a system, at least for conditions as they exist in this country, is likely to be confined to mountain grade work, where the advantages of regeneration can be secured. On the other hand, as the high potential direct current system has been developed with these same features, there seems little to warrant the additional complication of the three-phase trolley.

During the last decade the relative merits of single-phase alternating current and high potential direct current systems have been freely discussed, and many examples of each system have been installed and have been operated for a sufficiently long period to enable a logical opinion to be formed as to their relative merits. It would be impossible to enter into a detailed discussion of this phase of the subject in a paper of this length, but, judging from the results of operation, as published, and the number of single-phase interurban roads that have been changed from single-phase alternating current to direct current, and from the number of direct current roads now in successful operation, and the fact that no roads adopting higher direct current potential have changed, and the present ratio of alternating and direct current work now under construction and contemplated, it would seem safe to infer that at present, at least, the higher potential direct current road has a decided advantage over all other systems for heavy traction work.

What the future has in store no one can say. The alternating current system or some modification of it may be developed along lines that will enable advantage to be taken of its good features, and its inherent limitations to be overcome. And again, new modes of power transformation may come into use, such as rectifying alternating current to direct current when the advantages of the alternating current secondary distribution could be combined with the excellent characteristics of the direct current railway motor. But if we start speculating on the future, there is no limit to the range of our imagination.

There has recently been said, both in the technical press and elsewhere, a great deal about what pople are pleased to style "The Battle of the Systems." Some people have taken the attitude that electric railway developments have been hindered because all manufacturers of electrical apparatus are not agreed upon the best system for heavy traction purposes. Such people are prone to infer that such a condition of things is hindering development and that the manufacturers are responsible for this condition. As a matter of fact, such differences of engineering judgment, when there are several different methods of attacking a problem, must, in the long run, be beneficial to the railroads rather than harmful, as without such differences of judgment, the possibilities of the art can at best be but imperfectly developed. When any art has been developed to a reasonable state of perfection and the fundamentals have been well considered and thoroughly tried, and after the process of eliminating the less suitable factors and perfecting those which have shown themselves capable of meeting the necessary demands, under actual service conditions, has been carried to the point where our knowledge, based on experience, enables us to retain the good and reject the bad, then and not until then, is the time to talk of standardization. An attempt at standardization when an art is in a more or less embryo state is likely to work a permanent harm, inasmuch as it limits our knowledge of the broader engineering possibilities that might be brought to bear upon the subject. This question is of such importance to-day that it is worthy of consideration from both sides.

This so-called "battle of the systems" to-day is, as we all know, applied to heavy traction between single-phase and high-voltage direct current. Briefly, there are two courses open: to attempt to standardize one, or to try both. First, let us imagine that we are living under such conditions that an imperial edict has been issued that single-phase is par excellence, and that henceforth every railroad in the country that wishes to be electrified

must use this system. This is not very far from what has happened in Germany. The first fruits of such a condition might possibly be that a great amount of talent would be focussed upon one subject and that developments along certain limited lines might be stimulated. Also, the customers or railroads would be relieved of any worry concerning the selection of the correct system. There would be no choice in the matter; they must take what was presented or leave it. Under such conditions, the field of research and development would be limited to such an extent that any inherent limitations in this one system of electrification would literally form a stone wall across the paths of progress. If there are inherent limitations in any system and we insist on its adoption, we are hindering rather than helping the permanent sound progress of the art. On the other hand, when there are two or more systems that are recognized as competitors, and there are, as it were, opposing camps, one side championing one system and the other side championing the second system, we are building on broader foundations. As a matter of fact, the battle of the systems is merely a bogg—the selection of the best electrical apparatus to meet the service conditions in any particular case is the settlement of engineering details—not the adoption or rejection of a system.

There are some engineering firms that have thoroughly tried out all the apparatus which has been developed up to the present time, and their judgment in these matters is tempered by experience and costly tests, and the railroad companies are getting the benefit of this experience.

The development of the higher potential direct current railroad is of peculiar interest, as the apparatus used has gone through such a logical sequence of evolution. It is just about a decade ago that we began to recognize that 500 or 550 volts was no longer the standard potential for railway work. The voltage had gradually been raised from these figures to 600 volts, until there were more roads operating on 600 volts than at any other potential. When this condition was recognized, 600 volts was talked of as the standard. The evolution from 500 to 600 volts was largely brought about by a gradual increase of the traffic on existing systems, the raising of the voltage being the simplest and cheapest method of meeting the severe demands. There have been isolated cases of roads operated at 700, 750 and 800 volts, and the step from these potentials to 1,200 volts was a comparatively small one. It should be specially noted that the increase from 500 to 600 volts made no difference whatsoever in the design, construction and operation of the equipments. When the jump to 1,200 volts was taken, it was made for purely economic reasons, and no radical changes were made in the equipment. To retain the good and well-tried features of 600-volt control, a very simple piece of apparatus called the "dynamotor" was devised which enabled the control and auxiliary circuits to be operated at 600 volts and the main motors to use the higher potential. The only change in the motors to suit the higher voltage was that they were insulated for 1,200 volts instead of 600 volts, the common arrangement being to operate two motors in series so that 600-volt windings were still used. The adoption of commutating poles on railway motors greatly facilitated the raising of the trolley potential without the introduction of complications. The marked success that attended the operation of 1,200-volt apparatus under severe service conditions encouraged further steps along the same line with the result that some roads of 1,500 volts were installed. The results were equally satisfactory. Most of the roads at present operating at higher direct current potentials are in the nature of interurban railways but some, however, approximated steam railroad conditions. In all cases the apparatus has proved itself as well suited to the severe conditions as the older 500- and 600-volt apparatus had. Under these circumstances it is not surprising that a still higher direct current potential should have been considered for a heavier class of service. In 1912, just five years after the first 1,200-volt road was put into successful operation in this country, 2,400-volt direct current was adopted as the most suitable system to meet the peculiarly severe conditions existing on the Butte, Anaconda & Pacific Railway—thus direct current apparatus has evolved from a small beginning until it has reached a stage where it meets the demands of the heaviest traction undertakings contemplated.

This is as far as we have gone at present in this direction, in actual practice, but there seem no logical reasons or limiting conditions that we know of at present which would prohibit the use of still higher direct current potentials.

Since the initial adoption of 1,200 volts, the extension of its use has been exceedingly rapid, and it may now be regarded as the standard for all new interurban railways. In some cases where marked economies can be secured 2,400 volts may be used in interurban service. One example of this is already under construction, viz., the Michigan & Chicago Railway.

The first road to adopt 1,200 volts in this country was the Pittsburgh, Harmony, Butler & New Castle Railway. This road started operation in 1907. Since this date, the extension of high potential direct current railways has been exceedingly rapid, as shown in the following table:

Date of installation.	No. of roads.	Total road mileage.
1907	1	41
1908	2	134
1909	0	0
1910	6	424.6
1911	2	201
1912	3	196.5
1913-14	17	1061
Totals	31	2058.1

Most of the roads are in the nature of interurban railways, but it should be noted that as far as we can see the vast majority of the heavy traction work now under construction or contemplation will employ direct current apparatus and this will, in most instances, be operated on "higher potentials."

We are apparently fast coming to recognize that there is such a thing as "a science of development" and that such a science among other factors must include the following fundamentals:

(1) An accurate determination of the actual operating conditions which will enable us to settle definitely what is wanted.

(2) The co-ordination of the work of a large number of differently trained men, so that the finished product may embrace the experience of each worker in his particular line, and thus become in every detail the product of experts.

(3) The confidence and co-operation of the users and makers of apparatus both before and after its manufacture, this co-operation to continue in some form or other during the useful life of the machine.

(4) The standardization of apparatus when such will be profitable to all concerned.

(1) There are, perhaps, many who do not realize the costliness of determining what is wanted to suit a par-

ticular set of service conditions. An accurate determination of the precise requirements will often necessitate months of exhaustive investigation, often including costly tests. This is particularly true in large undertakings. If we compare the work done in this direction to-day with the older haphazard methods of designing machinery first and seeing whether it would do the work afterwards, it is apparent that the art has benefited enormously by the work of the large corporation along these lines. Some phases of the research and development work undertaken to-day are so costly and require such a large staff of expert workers that no small engineering undertaking could shoulder the burden, as assumed by the large corporation.

(2) The proper co-ordination of the work of a host of men who are contributing to the design, manufacture and testing of electric railway apparatus is no small part of the Science of Development. The extent of this work is enormous, including as it does, preliminary proposition, final proposition, designing, drafting, actual manufacture and work incident to following apparatus through the factory, assembling, testing, installing, and preliminary operation. The final cost of the apparatus depends largely upon whether this co-ordination of work is done in a scientific or unscientific manner.

(3) A whole paper might be read with profit on the subject of the confidence and co-operation between the user and the maker. Upon the encouragement and extension of what we might call "the modern business idea," the rapidity with which we are going to develop in the future must largely depend. The successful development of electric apparatus for traction purposes depends on "how it is made" and "how it is used." The manufacturer is dependent upon the user just as the user is dependent upon the manufacturer. An ounce of mutual confidence and co-operation will do more towards the development of the art than a ton of fault finding and mutual distrust. In the broadest sense, the aims and objects of both parties are identical. The user wants the best obtainable for his service and the maker wishes to produce the best and most efficient apparatus, as upon this his reputation and future business depends. The work of all parties concerned is in reality the part of one great plan.

(4) The correct time at which the standardization of electric apparatus should be attempted is a science in itself, e.g., it would undoubtedly be profitable to all concerned if all trolley systems would co-operate with the manufacturers in using standard apparatus, especially standard railway motors and standard control equipment, where such standards will fulfill the requirements. There will, however, always be special conditions arising that will demand special apparatus, and the things that dictate these special requirements are many and varied, e.g.: Who could have foreseen that the fashion of ladies' skirts could affect the design of railway motors? But such has been the case—the hobble skirt gave birth to the low-step car—and the low-step car required a new design of motor.

The standardization of all apparatus that is used in large quantities and has reached a high state of perfection would be a great asset to the industry.

On the other hand, until we have more experience with the different systems of electrification, it would seem unwise to lay down too definite standards for heavy traction work, although it might be profitable to standardize such things as trolley voltages that would vitally affect the future development of the art as much as the present.

In conclusion, it is well to emphasize one point, namely, that modern engineering involves, above all things, the study of economics. Yesterday we were finding out how to do things—to-day we are striving to find out how to do them more cheaply than yesterday. To combat the increased cost of living and of labor, etc., and the generally more complicated social and commercial conditions under which we are living, the work of the scientist and the engineer is to teach the world at large how to do for one dollar that which they could not do for two dollars yesterday.

AN IMPROVED TUNNELING MACHINE.

IN Fig. 1 is shown the side view of an improved pneumatic machine designed for driving an 8-ft. tunnel in rock. The machine is the invention of Mr. O. O. App, and is manufactured by the Terry, Tench & Proctor Tunneling Machine Company, New York.

The present design is a modification of a previous machine, the first of its type, introduced in 1908. This was practically operated in a rock tunnel in New York City, where it developed a capacity for cutting at the rate of from 1 ft. 4 in. to 3 ft. 4 in. per hour. While the improved machine is constructed on the same general principles as its predecessor, it embodies important modifications in detail. Through six years of experiments and tests in actual service conducted by the inventor, every detail has been carefully worked out and perfected to the point where it is now ready to be placed on the market.

As every engineer familiar with previous developments of this character knows, failures of tunneling machines in the past have been due chiefly to lack of capacity to stand up in all kinds of rock. One of the main problems has been to find a material for the vulnerable parts that would meet the drastic service requirements.

In the machine here illustrated, the chief difficulties have been to make it take care of itself automatically and to have the cutting tools and tool holders of the proper shape and quality to stand 1,000 rapid-fire blows a minute, each of sufficient power to chip ½ in. or more of rock.

An ingenious design of drill, worked out by the inventor, has successfully overcome the first of the above two troubles; the other has been solved by the use of vanadium steel for the cutting tools and the moving parts and other parts subject to wear of the drills. This has been clearly demonstrated by the results of actual service tests of the machine operating in the hard rock formation along the Harlem Ship Canal, in cutting the channel through which the greatest difficulty was experienced in the construction of the canal.

An unusual combination of hardness and toughness is essential to meet the duty placed upon the steel in this class of service. Probably no severer test could be given these properties of a steel than in this kind of a machine. It is because it combines these characteristics in an exceptional degree that vanadium steel has been used. Formerly, cutting tools 2 in. square and 12 in. long of high-grade carbon steel were used; whereas they now use tools 1⅜ in. square and 4½ in. long. Breakages have been practically eliminated and wear on the tools reduced. The inventor, to whom credit for the development of the device in all its details is due, claims that the type of steel used has made possible the achievement of a practical, efficient machine that will cut rock tunnel commercially.

The general construction of the machine is shown in the accompanying illustrations.

Sixteen 3-in. hammer drills are mounted on a massive cast steel revolving head with four arms or shafts. Each drill cylinder passes through an arm of the head and is

firmly held in a swivel holder, thus permitting changing the hammers to the proper angle with the face of the rock.

Compressed air is supplied to the drills at 80 to 100 pounds pressure through the main horizontal shaft on which the head is mounted. This shaft is rotated by a worm wheel 3 ft. 4 in. in diameter, operated by a 25-h.p. air engine geared 200 to 1.

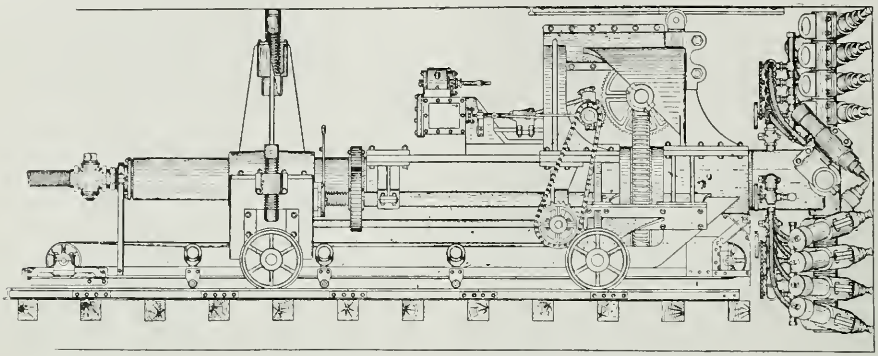


Fig. 1.—Side View of 8-ft. Tunneling Machine.

The shaft and engine are carried in a main horizontal frame with front and rear vertical transverse diaphragms, mounted on wheels.

In the upper part of each diaphragm are screw jacks which are operated to engage the roof of the tunnel and hold the machine firmly in position.

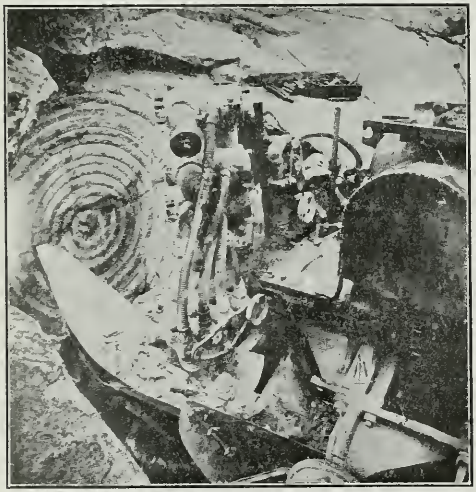


Fig. 2.—Showing Face of Bore Made by Tunneling Machine.

The machine is advanced by a pair of horizontal, longitudinal screw jacks 4 in. in diameter and of 36-in. feed. These connect the front and rear diaphragms and move them back and forth relative to each other, being operated by the central shaft by means of spur gears.

When the machine is in operation, the screw jacks move the front portion of the machine forward ½ in. for each complete revolution of the head. This action thus permits each cutting tool to carry positively a ½ in. chip of rock; and the machine thus removes a ½ in. layer of rock from the entire face of the tunnel for each revolution of the head.

The muck is removed by a belt conveyer, suspended from the forward diaphragm and carried by a pair of rear wheels. This is operated by a 2-h.p. electric motor, and delivers into dump cars on a track following the machine.

One of the most interesting details is the improved type of drills, which are so designed that they are automatically governed by the character of the rock. The cutting tools have a slight longitudinal movement in the drill cylinders and are provided with ports which control the exhaust. They do not reciprocate; but are held in one position or another and receive the impact from the hammer, which weighs 25 pounds and strikes from 1,000

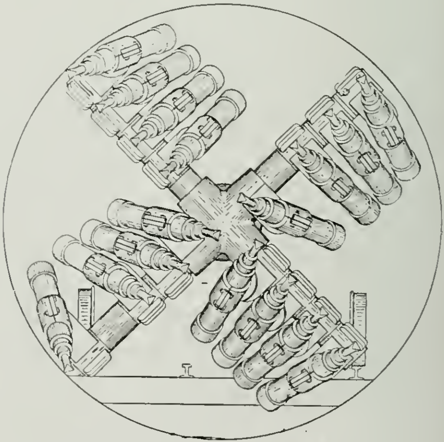


Fig. 3.—Front View of 8-ft. Machine.

to 1,200 blows per minute. When the pressure against the cutting steel is sufficient to overcome the constant pressure in the rock drill, it moves slightly backwards and opens the exhaust port, putting the hammer in operation against the head of the cutting steel. This action continues as long as the machine is in operation, and the cutting steel is forced against the rock with a pressure

of about 100 pounds. If the resistance against the point of the cutting steel becomes less than 100 pounds, through soft rock, open fissures or other reasons, the interior pressure forces it forward, closing the exhaust port and stopping the action of the hammer piston. If the machine is still continued in operation, the cutting steel acts as a gouge, milling off the tunnel face until the resistance is great enough to force it slightly back in its seat, when the hammer action is resumed, thus maintaining uniform regular action and automatically stopping the hammers when they are not needed.

The tool holders are so designed that the entire set of sixteen drills can be changed in 15 minutes. The cutters are so arranged as to remove all of the rock in the face of the heading and provide clearance for the machine.

The muck is removed by the conveyer before any accumulation can interfere with the operation of the cutters in the lower part of the tunnel.

All parts of the machine are accessible while it is in operation in the tunnel.

This machine can be controlled and operated by one man and is expected in ordinary rock to have a capacity of from 25 to 50 lineal feet of 8-ft. tunnel in 24 hours.

The advantages of an efficient tunneling machine are readily appreciated. Such a machine offers possibilities for large economies in the cost of construction work. The present demand for a device of this kind to drive subway, aqueduct, hydro-electric, irrigation and pneumatic tube tunnels furnishes a wide field of usefulness.

KOOTENAY CENTRAL RAILWAY NEARING COMPLETION.

While on a tour of inspection through British Columbia last week, Mr. J. G. Sullivan, chief engineer of the western lines of the Canadian Pacific Railway, stated that about 20 miles of track beyond Spillimacheen was completed on the Kootenay central line south from Golden. It is expected that the entire line, from Golden to the junction point with the Crow's Nest line near Ft. Steel, will be open for traffic this season.

The new line, which will afford direct railway communication from the Crow's Nest to the main line of the C.P.R. through the Columbia valley is 160 miles in length. Sections from both ends have been finished for some time, the service being placed in operation from Golden to Spillimacheen, a distance of about 40 miles, several months ago. The Kootenay Central opens up a large tract of fertile land through the Columbia valley.

Discussing the work being carried on by the C.P.R., Mr. Sullivan said that the company was laying 600 miles of new track in the west this year. Another 80 miles of double-track line would be ready for operation in British Columbia by October next.

Ballasting is now proceeding on the 34-mile stretch of double track east of Kamloops, and on a nine-mile section west of Kamloops. Tracklaying is now proceeding on the 28-mile portion between Revelstoke and Taft.

The attitude of unconcern and doubt at first prevalent in connection with the Beaver Lake gold fields near Saskatoon, Sask., is rapidly changing into one of interest and importance as the result of the discovery of much definite and encouraging detail. Over 1,000 miners and prospectors are said to be already on the ground, and the mineralized area is stated to be quite extensive and very rich.

COST OF SUBWAY CONSTRUCTION.

Diagrams for facilitating preliminary estimates of cost of subway construction have been prepared by Mr. Frank H. Carter, Designing Engineer, Boston, and have appeared in "Engineering and Contracting," to whom we are indebted for the following concerning them and their use:

The art of subway construction has advanced so rapidly towards certain standards since its inception by the city of Boston about 20 years ago as to warrant a survey of present types and their costs.

The practice to-day may be said to have narrowed to two standard sections for two track subways, the single tube with arch roof or with flat roof. The former has certain advantages in the matter of ventilation over the

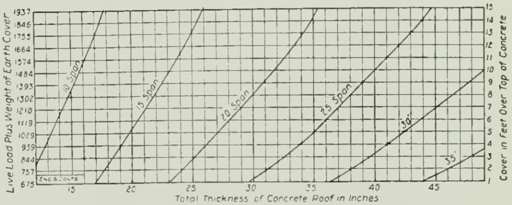


Fig. 1.

flat roof and at the outset was supposed to be cheaper per lineal foot.

Both cross-sections are now generally designed to safely withstand the stresses consequent upon the removal of part of the earth backing on one side of the structure arising from the construction of cellars for adjacent buildings or the construction of sewers. Were it not for this provision, the arch section would undoubtedly be cheaper than the flat roof.

The flat or nearly flat invert has been developed with due consideration of the opinions of the engineers of Maintenance of Way with respect to depth of ballast.

Clearance lines have been adopted from a study of the possible use of the subways for the transfer freight cars, with a centre to centre distance between tracks of 12 ft.

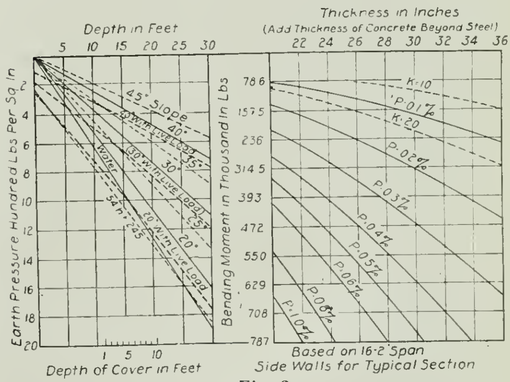


Fig. 2.

The allowable unit of stress in concrete and steel for parts of structure, subject to loads with impact, has been 600 lbs. per square inch for concrete in compression and 12,000 lbs. per square inch for steel in tension; for sides

and invert of the structure, subject to quiescent earth pressure, unit stress of 800 lbs. per square inch for concrete in compression and 16,000 lbs. per square inch for steel in tension.

Live and dead loads somewhat as follows were specified for the Cambridge Main Street Subway, being varied slightly from time to time to suit the situation.

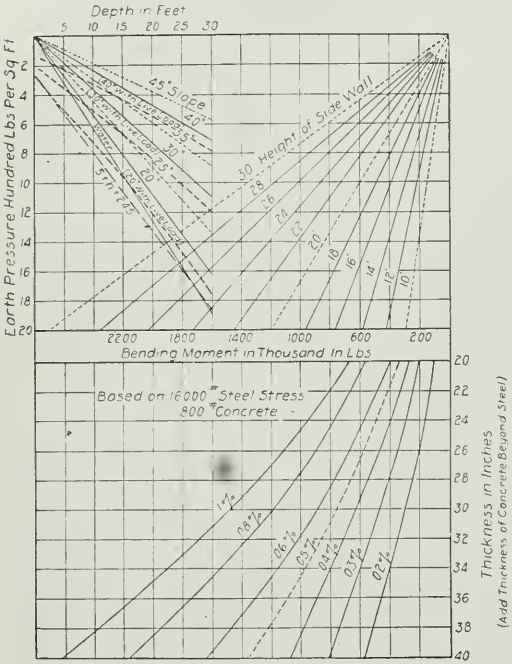


Fig. 3.

All parts of the structure under streets where the depth of cover from street surface to top of roof is 2 ft. or less, except floor or roof system girders, or beams or slabs of 30-ft. span as modified hereinafter, shall be designed for an assumed live load, including impact, of 500 lbs. per square foot or a load of 30,000 lbs. on each of two wheels, spaced 10 ft. on centres, where the latter cause greater strains. Where the depth of cover exceeds 15 ft. this loading shall be taken as 250 lbs. distributed, or 15,000 lbs. on each of two wheels. Where the depth of cover is between 2 ft. and 15 ft., the loads shall vary with the depth and shall be determined from the formula:

$$L = \frac{(28-d)}{13} \times L^\circ \text{ in which}$$

L = the load to be used.
d = the depth of cover.
L° = the corresponding load in case the cover is 15 ft. or more.

The distribution of concentrated loads through the earth (and concrete in the case of a reinforced concrete roof) in addition to the reduction for depth of cover, shall be assumed a trapezoid in a vertical plane at right angles to the direction of the span, 2 ft. wide on top and sides sloping outwards ½ to 1. Live loads for floor or roof system girders carrying over 100 and less than 200 sq. ft. of roof may be reduced 10 per cent. before applying other corrections; over 200 and less than 300 sq. ft., 20 per cent.; over 300 and less than 400 sq. ft., 30 per cent.; over 400 and less than 500 sq. ft., 40 per cent.; over 500 sq. ft., 50 per cent. Where the span of a beam or slab is over 30 feet, excepting as provided for the floor or roof system girders as above, uniform live loads may be reduced before applying other corrections 10 lbs. per square foot for each foot of span more than 30.

In general, two-track subway construction to-day will cost from $250 to $300 per lineal foot, depending upon the character of the material through which it is built as well as the depth of rail below the surface of the ground. Earth excavation for subway construction including the removal or support of street railway tracks during construction and street surfacing and the complete restoration of both, also the sheeting and bracing of trenches and underground water pumping will cost from $2.50 to $5 per cubic yard with an average perhaps of $4 per cubic yard. Concrete will cost from $8 to $12, including labor and materials but exclusive of the cost of steel reinforcement or its placing. Steel reinforcement will, of course, vary with the market but may be estimated at 2 cents per pound with an allowance of ¾ cent per pound for cutting, bending and placing, or at the rate of $15 per ton of 2,000 lbs. The item of cutting, bending and placing steel may be reduced to $8 per ton under proper management.

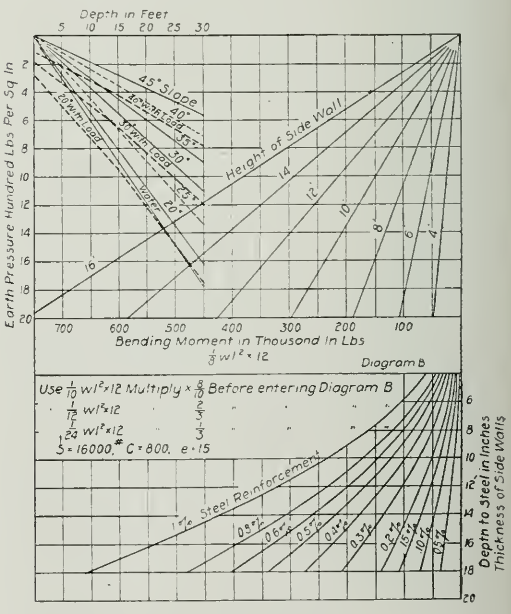


Fig. 4.

Thickness of Concrete.—The thickness of the side walls of the arch section should be decided only after study of the stresses in the arch proper and the consequent economical thickness of the arch ring. This observation applies as well to the invert of the arch section because of the racking stresses at the lower corners of the section due to the assumptions in regard to deep trench excavations on one side of the structure. In other words,

the thickness of side walls and invert depends upon the arch thickness to a certain extent. This does not apply in the case of the flat section, the thickness of whose side walls is not closely related to the thickness of the roof. It is in this case, however, desirable to maintain the thickness of side walls and invert at the corner very nearly the same because of the racking stresses due to the assumption of a deep trench on one side of the structure.

Fig. 1 gves the allowable total thickness of roof for the specified loads and allowable unit stresses of 12,000 lbs. per square inch on the steel in tension and 600 lbs. per inch on the concrete in tension.

Fig. 2 gives the thickness of side wall for the typical section under the earth pressures specified and for the unit stresses of 16,000 lbs. per square inch tension in the steel and 800 lbs. per square inch compression in the concrete.

Fig. 3 gives the thickness of side walls for section greater than the standard in height.

Fig. 4 gives the thickness of side walls of sections less than the standard height.

Fig. 5 gives the thickness of side walls for section composed of steel beams placed vertically.

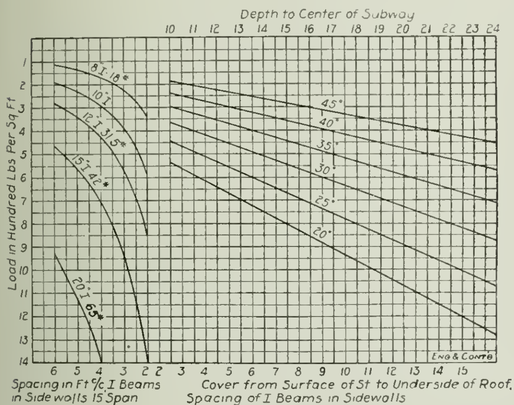


Fig. 5.

Fig. 6 gives the allowable thickness of side walls of typical sections of subway with no steel reinforcement assuming a tension of 60 and 120 lbs. per square inch in the concrete for *K* of 10 and 20 respectively.

The costs of subways per lineal foot given below in the table are from actual designs of sections, as shown in Figs. 7 and 8, for the arch and flat roof respectively. The cost of arch or flat section is practically the same pei lineal foot of subway for a depth of rail of 26.5 ft. below the surface. It is probable that the arch section is the more stable, better ventilated and perhaps more attractive in appearance, though obviously the latter feature is scarcely worthy of consideration.

For other widths of subway, the cost is almost directly proportional to the width of section, for instance, for a 25-ft. section our diagram reads $285 as the cost per lineal foot of structure. For a one-track subway, therefore, we should have (13 ft. span) $150 as the cost per lineal foot and for a six-track structure $900 per lineal foot of structure.

It is observed that this cost is about $11.40 per square foot and a variation of roughly 27 cents for each foot in depth. Indeed, Mr. Howard A. Carson states that subway stations of simple construction may be roughly estimated at $12 per square foot for a depth of rail below the surface of 20 ft., allowing 20 cents per square foot for each additional foot of depth below 20.

The removal and care of underground structures, such as sewer, gas and water pipes, must of course vary considerably from the very expensive work required, for instance, along the lower reach of Market Street, Philadelphia, down to some of the simplest work costing little or nothing.

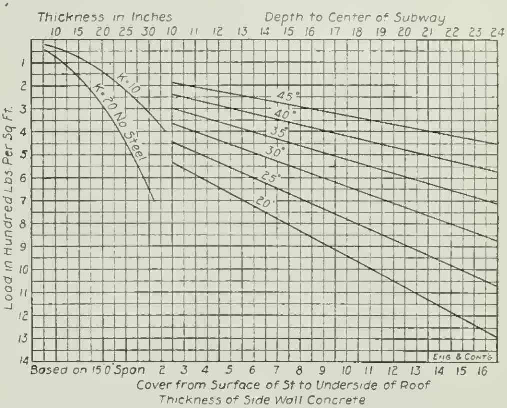


Fig. 6.

As an average at least $12 to $15 per lineal foot should be added to the cost given in the diagram as the cost for caring for underground structures.

With regard to underpinning of buildings along the line of construction, it is extremely difficult to give reliable or satisfactory figures. As a guide, however, the following three instances are cited, the authority of which is unknown. It costs to underpin along subway construction a building four stories in height 21 feet deep $122 per lineal foot of frontage. Another building of four

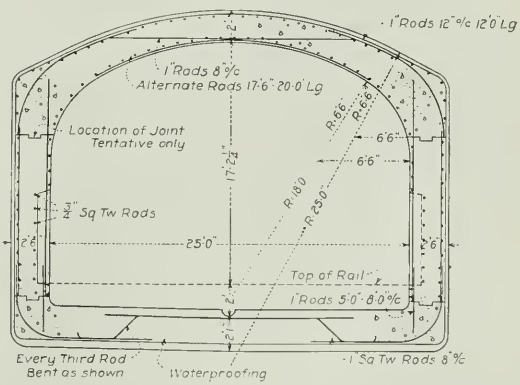


Fig. 7.

stories 11.6 ft. deep cost $120 per lineal foot of building frontage. Still another building of seven stories 20 ft. depth of underpinning cost $153 per lineal foot of building frontage. It is reputed that the foregoing costs are

from work done by the city of Boston. It is estimated that underpinning for a six-story brick building might cost $150 per lineal foot of building, while that for a two-story brick building might cost $90 per lineal foot of building with a graduated scale of prices for buildings of different heights.

Standard Arch Section.

21 ft. to rail—

28.8 cu. yds. excavation at $4.00	$116.00
8.19 cu. yds. concrete at $10.00	81.90
790 lbs. steel at $0.02¾	21.70
	$219.60

This equals $252 per lin. ft. with 15% added for contingencies and engineering.

27 ft. to rail—

35.6 cu. yds. excavation at $4.00	$143.00
8.19 cu. yds. concrete at $10.00	81.90
8.50 lbs. steel at $0.02¾	23.35
	$248.25

This equals $285 per lin. ft. with 15% added for contingencies and engineering.

21 ft. to rail—

27.4 cu. yds. excavation at $4.00	$109.50
7.73 cu. yds. concrete at $10.00	77.30
990 lbs. steel at $0.02¾	27.20
	$214.00

This equals $246 per lin. ft. with 15% added for contingencies and engineering.

Flat Roof Section.

27 ft. to rail—

34.0 cu. yds. excavation at $4.00	$136.00
8.36 cu. yds. concrete at $10.00	83.60
1,075 lbs. steel at $0.02¾	29.60
	$249.20

This equals $287 per lin. ft. with 15% added for contingencies and engineering.

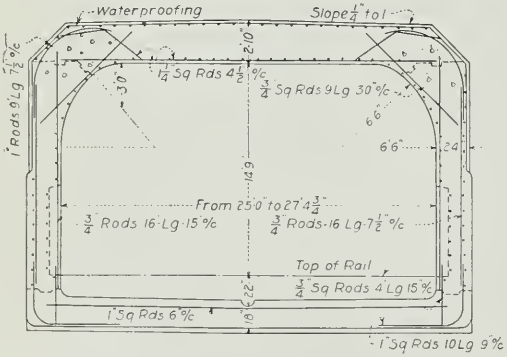


Fig. 8.

For underground structure add $12 to $15 per lineal foot and for waterproofing the outside with concrete protection to the waterproofing add $19 per lineal foot.

An example will illustrate the use of the curves for approximating the preliminary design of a sewer closely enough for the estimation of its cost.

It is required to design the roof and side walls for a rectangular sewer with a cover of 6 ft., span of 15 ft. and height of side walls of 10 ft.

First, from Fig. 1 we find for a cover of 6 ft. and a span of 15 ft. that the roof should be 20.6 ins. in thickness for 1.07 per cent. steel stressed 12,000 lbs. per square inch and concrete stressed 600 lbs. per square inch. Then, from Fig. 4 for a slope of material of 30° with super load, and for a distance below the surface of "*centre of depth*" of side wall, which consists of the sum of the following: Six feet cover plus 20.6 ins., the thickness of the roof plus 5 ft., which is one-half the height of the sewer walls or a total depth of centre of the side wall of $6 + 1.7 + 5 = 12.7$ ft., we enter the diagram at the upper left-hand

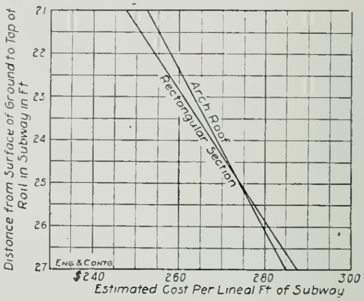


Fig. 9.

corner at 12.7, running down the 12.7 line to the diagonal "curve" marked 30° with load we read 570 lbs. per square foot pressure, we then trace along horizontally to the diagonal in the upper right-hand part of the figure marked 10 ft. height of side wall, we read 85,000 in. lbs. bending moment. Now, running down the 85,000 lbs. vertical line to the curve in the lower part of the figure to a wall 10 ins. thick to steel or 12 ins. thick total, we read 0.5 per cent. steel as the required percentage of steel for the given conditions.

Figs. 2, 3, 4, 5 and 6 are to be read similarly and are of considerable assistance in forming approximate estimates of cost or in checking designs of sections for construction.

THE ST. PAUL ELECTRIFICATION.

The St. Paul railway across Montana is the biggest thing of this kind that has yet been undertaken. The "Boston News Bureau" gives the following data. The electrification will comprise 440 miles of line. With normal traffic about 60 electric locomotives will be needed as against 82 steam locomotives. Electric power will be supplied by the Montana Power Company at 0.536c. per kw. It is estimated that 5,000 to 6,000 tons of copper will be required, or at the rate of 11½ to 13½ tons per mile. The work has already been commenced. The entire job should be finished by January 1st, 1918. It will cost about $8,000,000.

The engineering faculty of the University of Western Australia was established in 1913, and is conducting degree courses in civil, mining and electrical and mechanical engineering.

A recent report made to the Edmonton industrial association is to the effect that a virgin gold field has been discovered in the unexplored Liard River district of northern British Columbia, about 1,500 miles northwest of Edmonton, in a district which is declared to be extremely difficult of access, owing to the unfriendly attitude of the Indians inhabiting it.

SOME TRACK CONSTRUCTION STANDARDS FOR 1914.

THAT there is apparently no standard practice in track construction for street and radial railways is plainly evident from the widely differing standards of different public utility corporations. Transit companies go ahead, from year to year, improving their own standards by every possible means, but the indications of general standardization are not many. Examples of track construction standards for a number of cities are given below. For them we are indebted to "Electric Traction," and have selected those which will be of particular interest to electric railway men.

Columbus, Ohio.—Fig. 1 shows longitudinal and cross-sections of the track construction being used by the Columbus Railway, Power and Light Company, of Columbus, Ohio, at the present time. This is laid with Lorain section No. 434, 7-in. girder groove rails, 116 lb. to the yard, which are carried on Carnegie steel ties, section M-25, with the broad face turned up and spaced at 4-ft. 6-in. centres. The concrete base is carried up over the

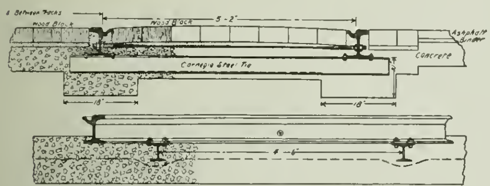


Fig. 1.—Columbus Railway, Power and Light Company.

base of the rails to form the foundation for the pavement. The concrete is carried to a depth of 12 in. below the base of the rail to form a girder 18-in. wide and is also brought down low enough between the rails to protect the ties. On top of the concrete a comparatively dry cement mortar is used in which to set the wood block paving. This variety of paving has been found to be very satisfactory and will be made use of by the company in its new work wherever possible. When 3½-in. blocks are used the steel tie rods are laid flat underneath the blocks. When 4-in. blocks are used, however, the tie rods are placed edgewise and the bottom corners of the adjacent blocks are chipped off in order to make the blocks come together.

The joint construction in Columbus has had a very interesting development. On one of the old types of track with 9-in. 94-lb. grooved-rail Lorain section No. 313 the joint was constructed by placing a piece of old rail having the same width base underneath the joint and buried in the concrete. Continuous rail joints were open up to include the base of the under rail which was turned bottom side up and the whole structure was bolted and bonded together and anchored in concrete.

The next joint development was used in connection with track employing the same weight and section of rail and was made by using a section of Carnegie steel tie of sufficient width to allow the fastening of the rail with Carnegie clips placing three clips on each side of the rail at each joint. This joint was bonded with compressed terminal bonds.

The present joint construction is the well-known Clark joint with some slight variation. In place of rivets eight drive-fit bolts are used with plates 30 in. long. A section of the Carnegie tie used as cross ties is cut off 36 in. long and placed underneath the joint parallel to the rail. These bottom bars are then welded to the rail, taking the place of the bottom thermit weld of the Clark joint and forming the bond.

Cincinnati, Ohio.—The standard track construction of the Cincinnati Traction Company is especially interesting for the thorough manner in which the sub-grade is drained and for the substitution of knee braces for the usual tie-rods.

As the gauge in Cincinnati is 5 ft. 2½ in., it is necessary to excavate for the sub-grade to a width of 9 ft. 2½ in., the depth being 21 in. Along the centre line of the track is dug a ditch 12 x 12 in. In about the centre of this is run a line of 4-in. farm tile surrounded by washed pebbles which come to within 2 in. of the top of the ditch. This space is filled with loam. In the track excavation proper is laid a 1:3:7 concrete mixture, standard oak ties being embedded in same with 6 in. underneath and about 2 in. on top. On top of this is a sand cushion for the paving. The company uses a 9-in., 140-lb. Trilby rail, Lorain section No. 402, with cast weld joints. Ties are spaced on 24-in. centres at joints where they are spaced on 28-in. centres.

Cast weld joints are used in tangents, with continuous joints at all breaks in grade and also in all curve work whether plain work or special work.

The company has found the knee brace preferable to the tie rod, as the great trouble with the tie rod was in the laying of the paving, and it was frequently found that a certain vibration was caused by the tie rod, resulting in the paving being pushed out of surface. The use of the knee brace has eliminated this trouble.

This type of construction has been in use in Cincinnati for practically seven years. The only change which has been made in the company's practice has been in the rail section itself, the rest of the work being substantially as adopted at that time. The results obtained from this construction have been very satisfactory as not a dollar has been spent on the foundation or drainage; the only expense the company has been subjected to has been an occasional slip of a joint, which has been, up to the first of this year, about ¾ of 1% of the total number of joints poured.

Lexington, Ky.—The standard construction of the Kentucky Traction and Terminal Company is to excavate a sufficient depth to allow 6 in. of crusted stone under the ties. After first thoroughly rolling the sub-grade and boarding, if necessary, any soft spots, should such be encountered, a course of crushed rock, broken to pass through a 2½-in. ring, is placed on the sub-grade. This is rolled with a 10-ton roller, and then the ties, 6 in. x 8 in. x 8 ft. and spaced on 2-ft. centres, are laid. Ties are all treated with Carbolineum. Eighty-pound A. S. C. E. open-hearth rail is used. The track is then tamped under traffic to a true surface and line. This tamping is repeated until it is evident that the ties are thoroughly bedded. The broken stone is then brought to a point 2 in. above the base of the ties, and the space between that point and the base of the rail is filled with a 1:3:5 concrete mixture. Over this a sand cushion is spread, on which to lay the paving.

A special cut granite block is laid longitudinally along the gauge side of the rail. This granite block is laid in a bed of a dry mixture of one of cement and two of sand. The brick on the outside of the rail and in the devil's strip are laid ¼ in. below the top of the rail so as to prevent breaking the skin of the brick with worn treads. All paving is laid level as this company's experience has been that it gives better riding conditions for vehicular traffic.

After the brick paving has been thoroughly rolled with a 5-ton roller, it is grouted with a mixture of one of Portland cement and two of sand. This grout is allowed to set for three days before vehicular traffic is allowed on the paving. The grout is applied in two applications, the first one being very thin so as to run into all crevices and voids. The second application, about the consistency of a rich cream, is carefully swept into all crevices, and is made before the first has had a chance to take an initial set.

The practice of this company is not to plaster the outside of the rail between the head and the base but to lay the brick snugly against the rail and allow the grout to fill this space.

An electrically welded joint, purchased from and applied with an Indianapolis Frog and Switch Company's outfit, is being used this year. Before allowing traffic on the track all joints are dressed off with a reciprocating rail grinder, so as to make the riding service absolutely true at the joints.

work trains, smaller material is delivered by a 3-ton Packard auto truck. For drilling holes for bonding, tie rods, etc., four Duntley electric track drills are used, and two Duntley electric grinders are employed for polishing rails in connection with bonding work.

Brooklyn, N.Y.—The chief feature of the standard type of surface track to be used in reconstruction of various sections of the Brooklyn Rapid Transit system during the present season, is that the ties are laid directly on the natural soil, which is a loamy sand, with good natural drainage. This company's experience has been that a ballast or concrete foundation is not necessary.

The natural soil is well compacted at the level of the sub-grade, which is 13 in. below the top of the rail. Long leaf yellow pine, 6-in. x 8-in. x 8-ft. ties, of prime inspection, are laid on this sub-grade on 2-ft. centres. A 1:3:6 gravel concrete (1½-in. washed gravel, graded) is poured between the ties and to 1 in. above them. On top of this is a 1-in. sand cushion for the 5-in. granite blocks. The rails, which are 7-in., 105-lb., grooved girder, in 60-

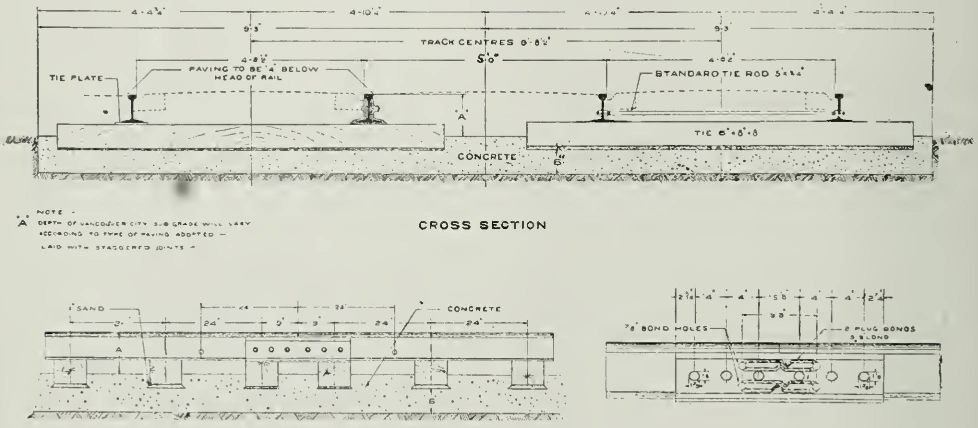


Fig. 2.—British Columbia Electric Railway Company Standard, Showing Sections and Detail of Drilling and Bonding.

Vancouver, B.C.—In its standard construction in Vancouver, B.C., the British Columbia Electric Railway Company uses 91-lb. high T-rail on its main lines and 70-lb. high T-rail on branch lines. For double track, the concrete slab foundation is made 18 ft. 6 in. in width and 6 in. in depth, partially embedding the ties. There is, however, a sand cushion under the ties varying in thickness from 1 to 2 in. The ties are rough fir (sawn) of standard size. Tie plates are used, being Australian gum ⅜ x 8 x 10 in. Other interesting details of construction are as follows: Spikes, railroad, 9/16 x 5½ in.; joint bonding, two 10-in. plug bonds, brazed with thermit; cross-bonding, two 300,000-cm. cables every 200 ft. of track; joint plates, continuous, suspended; bolts, 1 x 4½ in., oval neck, rolled thread; tie rods, ⅜ x 2 in. with ¾-in. terminals.

All track construction and reconstruction is carried out by the company's forces. Excavation is taken out with a No. A-1 Thew steam shovel to a depth of 20⅜ in. For doing the necessary concrete work before and after the track is laid five Koehring special street paving mixers, No. 14, are employed. Rails and ties are delivered on the job with a steam and an electric Brownhoist derrick and

ft. lengths, are fastened to the ties by 9/16-in. x 5½-in. spikes, four per tie, with 2-in. by ⅜-in. tie rods having ⅞-in. ends and spaced 6 ft. centre to centre. Thack joints are of the Falk cast welded type, weighing 190 lb. per joint and being placed opposite to each other. The space between the rail and the granite blocks is filled with a 1:4 cement grout while the interstices between the paving blocks are filled with a 1:1½ cement grout.

Davenport, Iowa.—The Tri-City Railway Company uses both the concrete base and ballast construction in its track work. Except in cases of badly drained or a settling sub-grade, the ballast construction is preferred, and as a general thing a concrete paving base is employed only when required. In all cases the company favors the concrete paving base, as shown in the accompanying drawing.

In the ballast type of construction, a trench, 8 ft. 6 in. wide by 29 in. deep, is excavated. After rolling, 6 in. of crushed rock, broken to pass through a 2-in. ring, is laid as the first course. On this are laid 6-in. x 8-in. x 8-ft. ties, and crushed rock is placed around them 2⅞ in. above their base. On top of this is placed a 1:3:5 concrete, 5 in. in depth; then a ½-in. sand cushion on which to lay the paving brick. The ties are, for the most part,

No. 1 6-in. x 8-in. x 8-ft. red oak, zinc chloride treated, and are spaced from 24 in. to 30 in., according to the prospective duty of the track. Standard spikes are used, without plates.

In the concrete base type the trench is made 9 ft. wide and 17 in. deep, from the top of rail. The concrete, a 1:3:5 mixture, entirely covers the ties, with 4 in. underneath and 6 in. at the ends. At the centre line of track

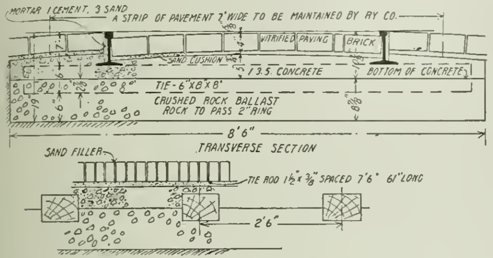


Fig. 3.—Tri-City Railway Company, Davenport, Iowa.

the concrete comes 11⅞ in. above the trench bottom. The concrete runs about 29.4 cu. yd. per 100 ft. There is ¾-in. sand cushion on top of the concrete, on which the paving brick are laid.

Of late years the Tri-City company has favored the six-hole continuous suspended joint with a concealed bond. There has been no one standard of bond, as the soldered, pin expanded and compressed terminal types have been used, each in considerable numbers.

While T-rail is generally preferred and used, when required by ordinance or possibly in case of very heavy street traffic, a 7-in. girder, Pennsylvania section 80-238, is used. Also, where required with the Shanghai rail, a special nose brick may be used, but the company's preference is the plain brick, as shown.

In general, it is the plan to secure permanence of construction by careful workmanship along the line of accepted standards rather than through attempting radical departures.

The rails used are the British standard section, girder type, 60 ft. in length. The straight track section weighs 110 lb. per yd., and the curving section weighs 116 lb. per yd., the extra weight on the latter section being due to the thicker lip or guard. The fishplates are 2 ft. in length, and are secured with six 1-in. bolts.

The Glasgow Tramways have recently decided to weld all joints on renewals and on new track. The welding may be either electric or by the thermit process. In the former case the fishplates are put on in the usual way, then welded in position; in the latter case, no fishplates are used.

About three years ago, a portion of track in the centre of Glasgow, where the traffic amounts to about four cars per minute, was welded by the former process, and up to recently there had been little or no expense for repairs.

Crown bonds are used at each joint whether the joints are welded or fishplated, in addition to cross-bonds at frequent intervals. The tie-rods, of mild steel, are 2½ x ½ in. in section and are spaced on 5-ft. centres. These are screwed at both ends with thick plate washers on each side of the rail web.

In new work, the class of paving will be the ordinary dressed granite sets, measuring 6½ in. deep, 3½ in. thick and varying from 6½ to 9½ in. in length. The tendency, however, in the city is to put down what is termed nidged granite blocks, the dimensions of which are 6 in. in depth, 6 in. in width and from 7 to 10 in. in length. These sets are hammer-dressed on five sides, ends, sides and top. Particular attention is paid to the top surface to have it perfectly flat. They are very closely jointed together in a bed of cement mortar, the proportions of the mortar being four parts of sand and one part of cement. They can either be grouted with cement or pitch, according to the time the traffic can be kept off. When sets of this kind are laid the street has a perfectly smooth surface. They are, however, very expensive, costing more than double the ordinary sets.

Some years ago, the Glasgow Tramways laid several miles of track on cross-timber ties. These extensions were several miles from the centre of the city, consequently the traffic is not so great. The track, however, has needed little or no repair all these years, but there is

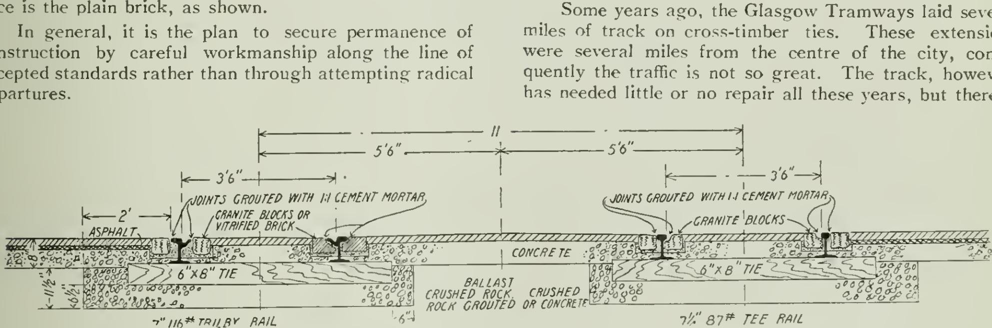


Fig. 4.—Los Angeles Railway Corporation, Trilby and High T-Rails in Paved Streets.

Glasgow, Scotland.—The method of track construction of the Corporation Tramways of Glasgow is practically the standard construction in that country, viz.: For double tracks, an excavation is made about 17 ft. in width by about 14 in. in average depth. The concrete base, about 7 in. in thickness, is made up as follows: Four parts of underneath the base with small granite chips, sand and one part of cement.

After the concrete has set hard, rails are laid in position to line and level, after which they are packed underneath the base with small granite chips, sand and cement, mixed in the proportion of 4:2:1.

now considerable difficulty in obtaining the necessary ties, and on new extensions it is planned to use only concrete base, as already described.

Los Angeles, Cal.—Fig. 4 shows the types of track construction to be used by the Los Angeles Railway Company during the present year. Both trilby and T-rail will be laid, but a city ordinance compels the use of the former section in paved streets, so that the greater part of the track to be laid this season will be of that type of construction. The trilby rail used is a 7-in. 116-lb. section, while the T-rail is a 7¼-in. 87-lb. section. With the trilby rail a six-hole continuous joint and brace tie plates,

spaced every third tie, are used; the T-rails are thermit welded.

For ballast the company uses crushed rock, crushed rock grouted, or concrete, to a depth of 6½ in. below the ties. In the two types of construction shown in the accompanying drawing, crushed rock is used under, around and between the ties to within 1 in. of their top. On top of this is poured concrete which embeds the base of the rails and forms the immediate foundation for the paving.

streets are shown in Fig. 5. In paved streets the earth is excavated to a depth of 20¼ in. below the top of the rail. In this trench is placed 9 in. of gravel ballast, which extends around the ties 1 in. above their base, while pit run gravel concrete, with proportions of 9:1, is used level with the top of the ties. The ties are long leaf Texas pine, 6 in. by 8 in. by 6½ ft., the track gauge being 3 ft. 6 in. They are treated in an open tank with hot carbolineum. The rails are 73-lb. T, with the ends sawed to

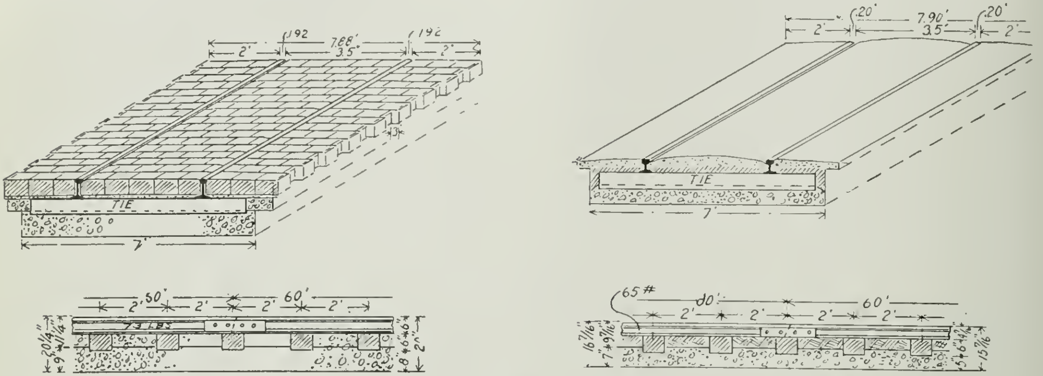


Fig. 5.—Denver City Tramway Company—Track Construction for Paved and Surfaced Streets.

Redwood ties, 6 x 8 in., are used; they are spaced at 20-in. centres.

The company paves its track to a point 2 ft. beyond the outside head of the rail, in accordance with city specifications. Where it paves in the trilby rail granite

a 10-deg. bevel, to provide for the bevel joint which is peculiar to the Denver construction. A 22-in. angle bar, weighing 11 lb. per ft., is used, together with 1-in. bolts. Under the splice plates 4/0 electric brazed bonds are used. The paving is crowned in the centre ¼ in. above the rail,

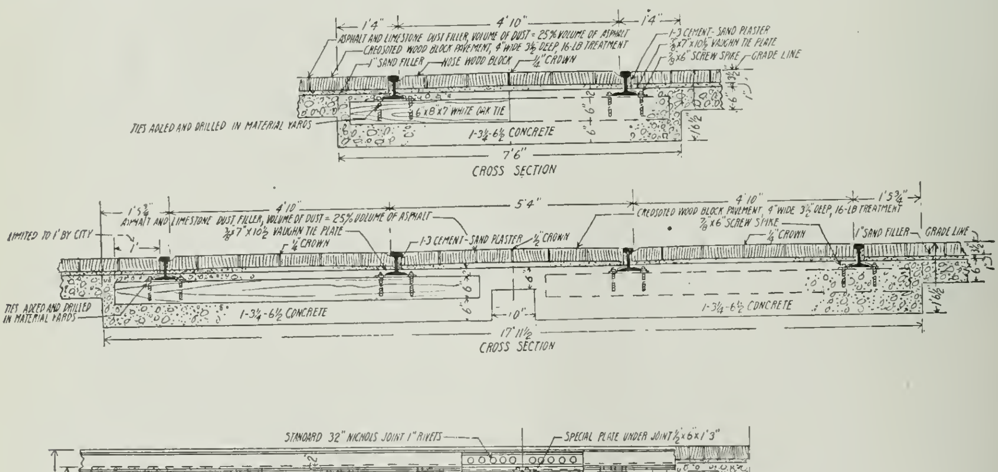


Fig. 6.—United Railways Company of St. Louis, Track Construction for 7-in. Trilby Rail.

blocks, vitrified or treated brick toothing are used; for the T-rail, bull nosed granite blocks are used. All are grouted with 1:1 cement mortar.

Denver, Colo.—The standard constructions of the Denver City Tramway Company in paved and surfaced

while the paving blocks are cut basalt, 5 in. deep, seven to the yard. These are laid on a 1-in. sand cushion and are grouted.

The construction in surfaced streets differs from that in paved streets in a number of particulars. The gravel

ballast under and around the base of the ties is 7 in. deep. In place of the concrete on top of this, as in the other type, earth is used, with 3 in. of screened gravel on top. This is crowned in the centre ½ in. above the rail. A 19-in. angle bar, 9.2 lb. per ft., is used, together with ⅞-in. bolts. The rail is a 65-lb. T-section.

A number of variations in the type of paving aside from that shown are used under different conditions.

The company's franchise provides that it shall maintain paving between the tracks and 2 ft. on the outside of each rail. Sometimes the company lays the paving to this 2-ft. line, and at other times makes arrangements with the city's contractor to pave a portion of this strip in. deep, with 6 in. under the ties and 5 in. above them.

The pavement of the tracks consists of brick, granite blocks or creosoted wood blocks, depending upon the pavement of the street outside of the tracks. The creosote wooden flange, shown in the drawing of the T-rail construction, will not be used on the work planned for this year as the city authorities have agreed to the trying out of granite flange blocks along the rail with wood blocks, brick or granite blocks in the centre of the track between the rows of flange blocks.

The main features of the various types of construction for girder tracks are the use of the solid concrete type of foundation; untreated white oak ties, of standard dimensions, laid 2 ft. centre to centre, the ties being

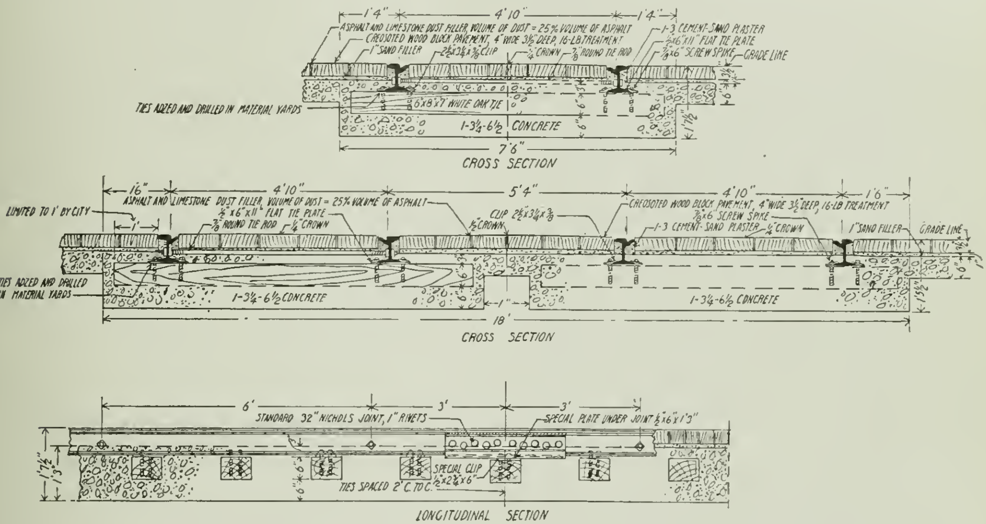


Fig. 7.—United Railways Company of St. Louis, Track Construction for 6-in. T-Rail.

with asphalt or whatever material is being used on the balance of the streets.

St. Louis, Mo.—During the past two years three types of track construction, for 9-in. trilby rail (Lorain section 132-440), 7-in. trilby rail (Lorain section 103-426) and 6-in. 100-lb. A. R. A. T-rail, have been used by the United States Railways Company of St. Louis, and these types of construction will be used on the work planned for the present year. Drawings of the 7-in. trilby and 6-in. T-rail types are shown in Figs. 6 and 7. The 7-in. and 9-in. trilby rail types differ only in the depth of the concrete foundation, the former being 15 in. deep, with 6 in. under the ties and 3 in. above them; the latter type is 17 adzed for tie plates by a machine in the material yard; ⅞ x 6-in. screw spikes; ½ x 6 x 11-in. flat tie plates on all ties; ⅜ x 2 x ¼ x 3¼-in. steel screw clips; 32-in. Nichols joint plates and ⅞-in. round tie rods.

The main features of the T-rail track construction are the same as those for the girder rail type, except that no tie rods are used, and instead of the ½ x 6 x 11-in. flat tie plates and the screw spike clips, a special patented tie plate is used. This tie plate consists of a ⅜ x 7 x 10½-in. flat soft steel plate sheared at the ends so that four ⅜ x 1⅛ x 2½-in. strips can be bent down over the rail base. The screw spike holes in the tie plates are located 1½ in. outside of the rail base.

INVESTIGATION FOR COAL IN NORTHERN CANADA.

A report from St. John's, Nfld., states that a schooner is now being equipped for a prospecting expedition to Hudson Bay, the main object of which is to investigate coal deposits in that area which can be utilized in connection with the operation of the Hudson Bay Railway, now under construction. A supply will also be required for the steamers. At present all the coal that is required in connection with steamer traffic to the Bay has to be conveyed there by Newfoundland sealing steamers that are used for freighting purposes in the summer months. They are the only vessels available that can withstand the wear and tear of navigation in these northern ice-laden waters.

Coal for the needs of the railway construction forces is conveyed by train from Winnipeg and Le Pas as the railroad progresses. When the line is opened to Port Nelson and terminals constructed there provision for a large storage for coal will be made. Its cost, however, in view of the lengthy transportation from Cape Breton by water and from Western Canada by rail will be a considerable item. Hence the present efforts to locate coal deposits near Port Nelson.

FUEL-BRIQUETTING INVESTIGATIONS.

THE manufacture of fuel-briquettes is now well established as a commercial process on the Continent of Europe, and, so far as the demand permits, in Great Britain, according to "Engineering," London. But in the United States, in spite of the vast fields of lignite, or brown coal, which are available, the industry cannot be said to have attained a proper foothold. Up to 1912, in fact, there were only twenty-four American plants in operation. For this reason the government arranged an exhaustive series of experiments on the briquetting of American fuels, and a mass of useful information has been collected. The results, which are given in great detail, are published in Bulletin No. 58 of the U.S.A. Bureau of Mines, and cover a period of eight years' work, from July, 1904, till July, 1912.

Briquettes are made by compressing the finely ground material into solid blocks, under a sufficiently high pressure. The blocks, if made from lignite suitably treated, are then cohesive, withstand handling, and keep their shape in the fire. But with anthracite, bituminous, and sub-bituminous coals, and even with certain lignites, sohesive blocks cannot be made without the use of a suitable binding material to keep the particles together. More binding material is required with anthracite than with bituminous coals, but peat, like lignite, can be briquetted by pressure alone. The binder which has been most commonly in use up to now is pitch; but, unfortunately, briquettes made with this material are very smoky in burning. Hence many of the United States experiments have been devoted to discovering suitable substitutes. In this respect the chief difficulty which has been encountered is that smokeless binders are generally not waterproof, and can be made so only at a more or less prohibitive cost. As shown by the experiments, however, the difficulty is not an insurmountable one.

The use of briquettes, so far as anthracite and bituminous coals are concerned, lies in the utilization of the fine or small coal. Although some fine coals coke when burning, most of them remain in their natural state, with the result that the dust clogs the draught, or falls through the bars with the ashes. Well-made briquettes, on the other hand, retain their form in the fire, and allow of a good air circulation being established. It follows that, where the difference in price between lump and fine coal is sufficient, they can be manufactured and sold at a profit. Other advantages which briquettes possess over ordinary coal are that they burn to a fine ash without clinker; the stoker's work is easier; the evaporative power, owing to the higher calorific value of the binder and the loss of moisture, is increased; more resistance is offered to weather; and the risk of spontaneous combustion is eliminated.

In the case of lignite, which requires no binder, and in its natural state contains a high percentage of moisture, the advantage of briquetting requires no demonstration. A series of tests reported in the United States bulletin shows that, where the moisture content of the samples varied from 33 per cent. to 42 per cent., from 24 per cent. to 32 per cent. was removed in briquetting, and the heating value of the fuel was increased by from 36.5 per cent. to 52.4 per cent.

These experiments are of the highest importance to Americans, but, in view of the smallness of our lignite supplies, do not possess the same interest for us. The principal European lignite fields are located in Germany and Austria-Hungary. In this country, where chiefly bituminous and anthracite coals are produced, it is with the working up of the "smalls" of these coals that we are concerned. Our output is smaller in proportion than that of other European countries, for the reason that briquettes have not been adopted to any great extent in our locomotives and steamships.

The plant required for making briquettes from anthracite or sub-bituminous coals includes a coal-elevator, pitch-cracker, pitch-elevator, measurer, mixer, disintegrator, compo-elevator, vertical heater, briquetting-machine, and briquette-conveyer. The coal is fed into the elevator direct from the wagons, and the pitch, after going through the cracker, falls into the boot of the pitch-elevator. Both are then discharged into the mixer and measurer, which consists of two screw-conveyers—a large one for the coal, and a smaller one for the pitch. The pitch falls from the smaller conveyer on to the coal in the larger conveyer below, and so becomes mixed with it. The compo is then elevated and discharged into the vertical heater, which forms commonly a part of the briquetting-machine itself. In the heater the mixture is heated up, either by a steam-jacket or by the injection of live steam, preferably superheated, and is at the same time more intimately mixed by revolving beaters. The semi-plastic material is finally fed into the moulds of the briquetting-machine, which are arranged on either a vertical or horizontal table, and a system of levers press it from both sides into rectangular blocks, under a pressure of about 2 tons per square inch. Facilities are provided for filling and discharging the moulds, for giving a rotatory feed to the table, and for varying the pressure. For the smaller eggette or ovoid briquettes, which are now in many cases replacing those of rectangular shape, a different type of machine is used, and the moulds are formed in the peripheries of rollers, which press on tangential feed-slides. In the case of lignite and peat briquetting, the material is forced through a tapered tube in a continuous stream, and is cut off by a wire cutter into cylindrical briquettes of the required length. Portable plants for railway use have also been designed, and a typical example was described in "Engineering" for April 3, 1914.

The English plant, by Messrs. William Johnson and Sons (Leeds), Limited, used in the American experiments, was substantially as above described, except that it was modified in several respects to meet the needs of the experimenters. The principal alteration made was in the measurement of the coal and binder. To ensure absolute accuracy, this was effected by the use of separate scales, instead of by differential conveyers. In the first American plant, by the Renfrow Briquet Machine Company, St. Louis, horizontal heating cylinders were used, fitted with worm-conveyers, instead of beaters. Otherwise the arrangement closely resembled that of the Johnson plant. But in the case of the second American machine, by the American Compressed Fuel Company, Chicago, a different design was adopted. After being measured, the coal was dumped into a steam-jacketed mixer, where the pitch, which had previously been melted and measured, was mixed with it. The mixture was then fed into a roller-press, and formed into briquettes of the eggette type.

For lignite, a German plant by the Maschinenfabrik Buckau Actien-Gesellschaft, of Madgeburg, was used. The lignite, before entering the tube-press, which created a pressure of 14,000 lb. to 28,000 lb. per square inch, was treated in a set of crushing rolls, a rotary drier, sieve, auxiliary crushing-rolls, and cooling-plates with scrapers. The equipment also comprised a small hydraulic hand-press for making preliminary experiments.

The experiments were divided into three periods. From 1904 to 1907 the work was carried on at St. Louis, and the Johnson, American Compressed Fuel Company, and Renfrow machines were used. From 1907 to 1910 at Norfolk, the Johnson and Renfrow (improved) plants were employed, together with a German Schlickeysen peat-machine. And at Pittsburgh, from 1910 onwards, the experiments were confined to the German lignite plant and to the small hand-press, although the English machine has been placed on its foundation.

The physical tests to which the briquettes were subjected were called the "drop" and the "tumbler," the absorption, density, weathering and compression tests. In the first, the briquettes were dropped on the floor, and the pieces, which were held by a screen with 1-in. square holes, were dropped again. This procedure was repeated five times, and the weight of the pieces, which, after the fifth drop, would not pass through the screen, was determined. In the tumbler test a weighed quantity of the briquettes (about 50 lb.) was rotated for two minutes at 28 revolutions per minute in a sheet-steel cylinder. The parts which were held by a 1-in. screen and a 10-mesh sieve were then weighed. The absorptive qualities of the briquette were tested by weighing, and the rate of absorption each day, and the time required for the absorption to become complete, or for the briquette to disintegrate, were determined. The density was taken by means of a Nicholson hydrometer, and the weather-resisting qualities were assessed by observation extending sometimes for as long as 286 days. For measuring the crushing strength a 200,000-lb. Olsen testing-machine was employed, although it is stated that the amount of handling which the briquettes will stand is given more accurately by the tumbler and drop tests.

The chemical tests included analyses and moisture tests, and extraction tests, using carbon bisulphide as a reagent, were made to determine the percentage of bitumen in the raw and the briquetted fuel. To determine the evaporative and burning qualities, the briquettes were burned under a stationary boiler. Special tests were also made on locomotives and on a torpedo-boat, and in domestic furnaces and foundry cupolas. The locomotive tests show that the evaporative efficiency of briquetted as compared with raw fuel is greater; that firing is easier; and that both the clinker and smoke produced are less. On the torpedo-boat it was found that there was no gain in smoke production, or in efficiency, but that the work of the stokers was lightened, and the boiler capacity increased. The domestic furnace tests proved that, for the low temperatures common in house-heating boilers, pitch is an unsuitable binder, as it volatilized and escaped unburned, or became deposited as tar. It also gave rise to too much smoke.

In the experiments the question of what binder can be used has naturally been investigated in great detail. The coal-tar pitch binders at present employed give briquettes which are waterproof, do not crumble during transport, leave little ash, and can be manufactured at a reasonable cost. Other binders, notably cereals and "sulphite pitch" (selpech) have an advantage over pitch, inasmuch as they are smokeless in burning, but they are unfortunately not waterproof, so that the briquettes crumble after exposure to the weather. Such briquettes can easily be rendered waterproof, but the cost has hitherto been considered prohibitive. The American experimenters, however, state that their investigations on this head show that the discovery of a cheap waterproofing process is not an impossible achievement. And the patentee of Middleton's starch binder declares that he has already solved the problem, using 2 per cent. of cereal and ½ per cent. of tar, against, in the ordinary process, 8 per cent. of pitch. The cost of manufacture, he claims, is cheaper than in the pitch process so long as the price of pitch is above 42s. 6d. per ton. He states that the fuel, after exposure to the weather for several weeks, shows practically no deterioration.

In addition to detailed experiments with various kinds and percentages of pitch, the bulletin reports the testing of a large number of other binders. These include creosote, asphalt, petroleum (both of paraffin and asphalt bases), lime, clay, wax tailings, and sludge; various wood products, such as resin, tars, wood pulps, and sulphite liquor; various sugar-factory residues, such as beet pulp, lime cake, and the different molasses; starches, slaughter-house refuse, and petroleum products.

In the tests of pitches it was found that the pitch obtained from the distillation of petroleum gas-tar gave the best results, although other pitches distilled from by-product coke-oven tar, illuminating-gas tar, and producer-gas tar proved quite satisfactory. Water-gas pitch, another binder tested, has an advantage over ordinary coal-tar pitch in that the production of free carbon present is only 10 per cent., as against as much as 30 to 40 per cent. with the ordinary material. The free carbon is useless as a binder, and acts merely as a diluent of the bituminous matter. In all pitches it is important to select a material that is not too hard. The actual hardness required varies with the time of year and the climate; but, generally speaking, it was found that pitch which becomes brittle when dropped into water at 55 deg. Fahr. is of the correct texture. The harder pitches have been robbed of the creosote and lighter oils during distillation, so that pitches from which these oils have been distilled off should be avoided. It is also better for briquetting purposes that the pitch should be prepared in this way rather than by distilling all the oil, and then reducing the pitch with the naphthaline and creosote oils, as is sometimes done. As an example of the disadvantage of using the harder pitches, it may be said that in one experiment with a pitch of this kind, 13 to 18 per cent. was found necessary to make good briquettes, while, when a pitch with the proper amount of light oils was tried, 6 to 9 per cent. proved sufficient. Other experiments show that from 7½ to 14 per cent. of volatile oils is the correct proportion to give the proper binding qualities, and that from 6 to 9 per cent. of pitch of this kind will make good briquettes from most bituminous and anthracite coals. To mix with a non-coking coal 10 to 20 per cent. of a coking coal is better than increasing the percentage of pitch.

Of the other binders tried, it was found that clay, lime, cement, magnesium oxide, plaster-of-paris, acid sludge, sugar-factory residues, slaughter-house refuse, and wood products are all unsatisfactory, although some of the last-named give good results in combination with other binders, and seem for that reason to deserve further investigation. Wax-tailings give fair results, but are not considered altogether satisfactory, while crude petroleum, although answering well, is deemed unsuitable for working on a commercial scale. Resin, used in conjunction with pitch or petroleum, and a percentage of lime to prevent smoking, makes a good binder; but here, again, the cost makes commercial application impossible. Asphalts are also rather too expensive in most places, and give only fair briquettes, but asphaltic tar was found useful as a waterproofing material in briquettes made with starch.

In fact, the only really good binders besides pitch were found to be starch or flour, and sulphite pitch. None

of these is waterproof, but a careful study was made of waterproofing processes, and, as stated above, it is believed that a successful and inexpensive process can be discovered. When using corn starch only 2 to 4 per cent. is required with ordinary coals. The briquettes made with this binder were found to be smokeless. They held their shape well in the fire until completely consumed, and, although the heat value of the binder is small, it leaves no ash. Messrs. Yeadon, Son and Co., of Leeds, are, we understand, constructing a plant for Russia to briquette lignite, with a binder made of finely ground meal and mazut, and a small proportion of pitch.

Sulphite pitch, also known as cell pitch, is made from the waste liquors which are produced in the sulphite process of manufacturing paper pulp from wood. Until recently these liquors had no commercial value, and their proper disposal was a serious matter, since, if discharged into rivers, they polluted the water and killed such fish as were contained in it. In making the pitch, the liquor is concentrated to a syrup in a sextuple-effect evaporator, and solidified into pitch as a thin film on two rotating steam-heated drums. With some coals, less than half the quantity of cell pitch is required as compared with ordinary pitch; but with others, in the American experiments, the percentage necessary was the same for each material. German experiments, on the other hand, incline to the smaller value. Briquettes made with this binder are smokeless and odorless, and the price of the material, if there are cellulose mills at hand, is low. In the Pollacsek process, used by the Hungarian government for its collieries, sulphite liquor is employed, and from 3 to 5 per cent. is found to give good briquettes. The briquettes made with sulphite pitch can be rendered waterproof by drying at a temperature of 300 deg. Cent., or by the addition of certain chemicals, the nature of which at present is not divulged. With the latter process, the cost of waterproofing is estimated at 1s. 6d. per ton of briquettes. It is thought at present that the sulphite process will be more useful for anthracite than for bituminous coals, but that it also will be widely employed in preference to pitch in briquetting ores for smelting.

The cost of manufacturing briquettes in England, exclusive of materials, is estimated at about 1s. 6d. per ton of briquettes, and, using 8 per cent. of pitch, the cost of the binder will be about 3s. per ton of briquettes. The cost of the binder, using 2 per cent. of cereal and ½ per cent. of tar, will be about the same, on Middleton's process, when the cereal costs 7*l*. 10s. per ton. In Germany the cost of making lignite briquettes, including all materials, works out at 7s. 6d. per ton, the lignite being taken at 1½d. per bushel.

There is evidently a large field for the development of this industry, and the briquetting of ores for smelting, which has not been investigated in the American experiments, is likely to be even more important than the briquetting of coals. Not only iron, but copper, nickel, and other ores can be made into briquettes with advantage.

EXPERIMENTS ON PAINT PROTECTION.

Some experiments recently carried out in Europe indicate that a single coat of paint gives iron greater protection from rusting than several coats. Different samples of iron were painted with one, two, three and four coats, respectively, and after a certain time it appeared that the iron under four coats was completely covered with rust, that under three coats was less affected, that under two coats was partly rusted, but the iron under one coat was free from rust. The theory suggested is that increase in the number of coats gives more corroding electric currents at the surface of the metal.

COST OF GOOD ROADS IN UNITED STATES.

Approximately $206,000,000 was spent last year on public roads in the United States, according to statistics prepared by the U.S. Department of Agriculture. In 1904 the total was only $79,000,000 In nine years the increase has been over 250 per cent.

This awakening on the part of the country to the importance of good roads has, experts say, been due in great measure to the principle of state aid to counties and other local communities. New Jersey began the movement in 1891, when it passed its State Highway Law. Massachusetts and Vermont followed a year later, but for the most part the other states were slow to move. In 1904, only fifteen had state highway departments; to-day there are only six that have not. In 1913, the individual states appropriated a total of $38,755,088, to supplement local expenditures.

The value of this state aid is, however, not to be measured by the figures alone, for the bulk of the money comes, and always must come, from the counties and townships. Thus, in 1912, the cash outlay by counties, districts and townships, was $137,493,985. Complete figures for 1913 are not yet available, but it is safe to estimate the sum at approximately $151,000,000. To this must be added some $15,000,000 to represent the value of the labor contributed instead of cash in districts where this practice prevails. Last year, therefore, local communities contributed, in round numbers, one hundred and sixty-six millions of dollars, as against appropriations from state treasuries of $38,755,088. The true importance of this thirty-eight millions lies in the fact that it means expert supervision of the expenditure of a considerable portion of the vast sum of two hundred millions. When each county built as it chose and when it chose, the services of trained engineers were usually out of the question. There was little opportunity to test innovations, little advance in the science of road-building, and there was also difficulty in arousing each county individually to do its best to improve conditions within its own limits. State aid has changed all this. The best engineering skill is available for all works of importance, there is co-operation and a constant stimulus to further improvements. The money contributed by the state not only builds more roads, but it makes better those that other money builds.

At the present time there are in the United States 20,741 miles of roads improved either wholly or in part by state aid. This is nearly the mileage of the French routes nationales, the system of great national highways which is the envy of every civilized nation. The routes nationales are, of course, only a small part of the total mileage of France, where practically every road of any importance is an improved road. Of the 2,226,842 miles of roads in the United States, 233,774 miles, or approximately 10 per cent., are classed as improved.

ONTARIO MUNICIPAL ASSOCIATION.

An interesting meeting, to be held in the first week of September, will be the annual convention of the Ontario Municipal Association. This association is made up of members of county, city, town, township and incorporated village councils and municipal officials. At its meetings addresses are delivered by specialists in various features of local government and administration, and the discussion of these addresses is always practical and generally very interesting and instructive. The association is also an important agency in the promoting of improvements in municipal legislation. The coming convention, which will be held on September 2nd and 3rd, at Toronto, promises to be unusually large and attractive.

A NEW DEFLECTION FORMULA FOR CONCRETE BEAMS.

In a paper read by Mr. G. A. Maney at the 17th annual convention of the American Society for Testing Materials a new formula was given whereby deflection can be calculated from the known loading and beam dimensions. The deflection, according to it, equals the product of the sum of the deformations at the two extreme fibers of the concrete, into a constant. It is based upon the property of the M/EI curve for any beam, that the deflection of the beam is proportional to the statical moment of the area under the M/EI curve. This curve is obtained by dividing each ordinate of the bending-moment curve by the product of the corresponding values of E and I, which are the modulus of elasticity of the material and the moment of inertia of the sectional area of the beam, respectively. The statical moment of the area under the M/EI curve between any two points on the elastic curve, taken about one of these points, is equal to the vertical deflection of this point from a tangent to the elastic curve at the other point, the beam being assumed to be horizontal.

The unit stress on the extreme fiber is equal to Mc/I. The unit deformation, e, of that fiber is therefore equal to Mc/EI and the total deformation in the distance dS along the elastic curve equals $McdS/EI$. Referring to Fig. 1, it is seen that this total deformation of the extreme fiber, divided by the distance c from that fiber to the neutral axis, is equal to the change of slope, $d\theta$, in the distance dS. Or

$$d\theta = \frac{Mc\,dS}{EI} \div c = \frac{M\,dS}{EI}$$

It will be seen that the term $M\,dS/EI$ is equal to the area under the M/EI curve for the distance dS along it; that is, $d\theta$ is equal to a differential element of the area under that curve.

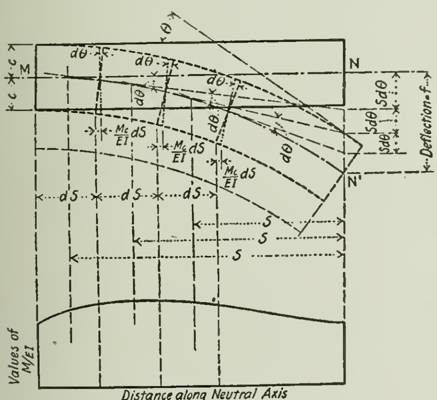


Fig. 1.—The M/EI Curve for Beam.

Now, let S equal the distance from any differential element dS to the point at which the deflection is desired. Then, referring to Fig. 1, it is clear that the deflection of N' from the tangent MN at M is equal to the sum of the products of each $Sd\theta$ along the elastic curve from M to N, S being measured from N'. Or

$$f = \Sigma\, S\, d\theta$$

But $S\,d\theta$ is equal to the statical moment of the differential element of the area under the M/EI curve about N', by the definition of statical moment. Therefore, the deflection of any point from the tangent to the elastic curve at any other point is equal to the statical moment of the area under the M/EI curve about the first point. (In this proof, as in all treatments of the elastic theory, it is assumed that the projection of the neutral axis after bending, upon its original position, is the same as its length before bending.)

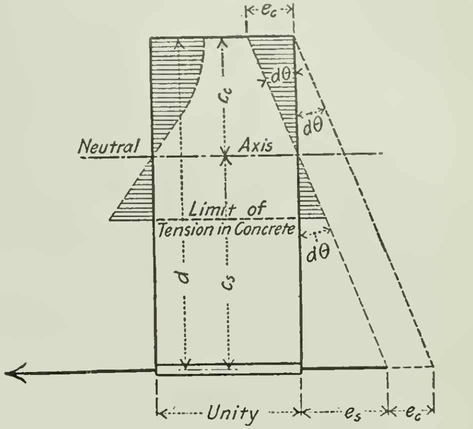


Fig. 2.—Showing Variation of Deformation and Stress.

This property for homogeneous beams may be expressed:

$$f = kl^2\,(M/EI)$$

The value for M/EI in equation (3) will be taken for the point in the beam at which the bending moment is maximum. Then the value of k is such that the statical moment of the M/EI area between any two points, which is equal to the deflection of one point with respect to the tangent to the elastic curve at the other, is expressed in terms of this maximum value of M/EI and the span of the beam, l.

It is evident that the value of k for any case is equal to the coefficient of deflection for homogeneous beams in the well-known equation $f = k_1 W l^3/EI$, divided by the coefficient for the maximum bending moment, which in general may be expressed as $M = k_2 Wl$, from which $W = M/k_2 l$. Substituting this in the last equation for deflection,

$$f = k_1 \cdot \frac{M}{k_2 l} \cdot \frac{l^3}{EI} = \frac{k_1}{k_2}\, l^2 \left(\frac{M}{EI}\right)$$

Comparing equations (4) and (3), it is seen that $k = k_1/k_2$. To illustrate, consider the deflection at the centre of a freely supported beam with a single concentrated load at the centre; that is, the deflection of the support with respect to the tangent to the elastic curve at the centre. The coefficient k_1 is 1/48, and k_2 is 1/4. Therefore the coefficient k in equation (3) will become $1/12 = 0.0833$ (see Fig. 3b).

The maximum deflection of a simple beam is equal to the deflection of the support from the horizontal tangent to the elastic curve. Usually the maximum deflection occurs at the centre of the beam, as in all cases of symmetrical loading. With irregular loading, it usually occurs near the centre of the beam. Then, by the property of the M/EI curve above referred to, we may express this deflection as the statical moment about the support of the area under the M/EI curve between the

point at or near the centre of the span, where the slope is zero, and the support. If this statical moment is expressed in terms of the maximum ordinate of the M/EI curve and the whole span, an expression is obtained of the form of equation (3), in which the coefficient k will equal k_1/k_2.

It may be of interest here to point out that M/EI equals the rate of change of the slope of the elastic curve, or the change of slope per unit distance. This may be seen by dividing equation (1) by dS, which gives $d\theta/dS = M/EI$.

The application of this principle to the deflection of reinforced-concrete beams consists in finding a convenient expression for the value of M/EI.

Let e_c and c_c be the unit deformation in the extreme fiber and the distance from the extreme fiber to the neutral axis, respectively, for the concrete, and let e_s and c_s be the same quantities for the steel. In a homogeneous beam, as above indicated, $e/c = M/EI = d\theta$, and is the same for both extreme fibers. In this case, since the

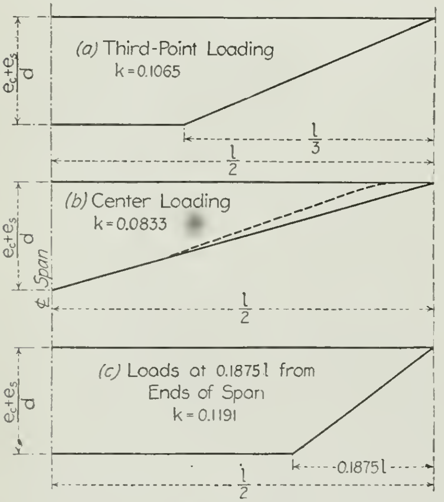


Fig. 3.—Showing Variation in Values of (Ec + Es)/D.

values of EI are constant throughout the length of the beam, e/c varies directly as M throughout the span.

In a reinforced-concrete beam (see Fig. 2),

$$\frac{M}{EI} = d\theta = \frac{e_c}{c_c} = \frac{e_s}{c_s} = \frac{e_c + e_s}{d}$$

Substituting this value of M/EI in equation (3), the following expression for the deflection of a reinforced-concrete beam is obtained:

$$f = k\frac{l^2}{d}(e_c + e_s)$$

This is based on the usual assumption that a plane before bending remains a plane after bending, which seems justifiable from the evidence of reliable tests herein referred to.

From the preceding analysis it is evident that the deformations of the extreme fibers are the only determining factors in the deflection, except the span, depth of beam, and load-distribution. It is also evident that the distribution of the stresses in the steel and concrete over the section has no influence on the deflection, except in so far as the stresses influence the deformations of the extreme fibers.

The influence of tension in the concrete might well be discussed here. From the principles of equilibrium it is known (see Fig. 2) that the effect of the tension in the concrete at low stresses is to reduce to some extent the compressive stresses in the concrete and the tensile stresses in the steel. This means that a stiffer beam might be expected in the earlier stages of the loading, as the steeper slope of deflection and deformation curves show.

For the reason, therefore, that tension exists in the concrete and that usually near the end of the beam the roads are bent up, the value of the $(e_c + e_s)/d$ curve, from which the deflection is obtained, will not have the same variation as the values of M.

Near the supports of a simple beam and at all points where the bending moment is small, we would expect considerably smaller values of $(e_c + e_s)/d$ than the value of M at such a point, relative to the value of M at the point of maximum moment would indicate. The values of $(e_c + e_s)/d$ would probably follow the dotted lines indicated in Fig. 3b, because of the tension in the concrete. A glance at Fig. 3b will show, and computations will prove that a small decrease in values of $(e_c + e_s)/d$ $(= d\theta)$ near the point about which moments are taken (the support, in this case), changes the value of this moment only slightly.

Values of k for maximum deflections under several conditions of loading are here given:

Beam with uniform load:
- Ends freely supported, $k = 5/48$ or 0.1041;
- Ends fixed, $k = 1/32$ or 0.0313.

Beam loaded at the third points:
- Ends freely supported, $k = 23/216$ or 0.1065;
- Ends fixed, $k = 5/144$ or 0.0347.

Beam loaded at the middle:
- Ends freely supported, $k = 1/12$ or 0.0833;
- Ends fixed, $k = 1/24$ or 0.0416.

DOMINION GOVERNMENT BUYS INTERNATIONAL RAILWAY.

On August 1st the International Railway became a part of the Intercolonial Railway and will be operated by the Dominion Government in future. Mr. Evan Price, superintendent of the Canada Eastern Division of the Intercolonial Railway, will superintend the operation of the new portion, which is 112 mi. in length.

OGDEN POINT BREAKWATER, VICTORIA, B.C.

The site of the proposed breakwater at Ogden Point is now the scene of considerable activity, the contractors having started work last week. Rip-rap is being hauled by towboats and scows from the Albert Head Quarries. The facilities for the transportation of this material are adequate for conveying 50,000 tons per month. Pile-driving to indicate the line of the breakwater has been completed, the extreme point being about 1,750 ft. from shore. The shore work in connection with the breakwater is almost complete, the site having been levelled off and the fillings completed. These fillings have greatly enlarged the land surface at the disposal of the government for the piers in connection with the breakwater.

It is expected that the work will be nearing completion in about eighteen months. The breakwater is of concrete construction, faced with large granite blocks

Editorial

ENGINEERING AT HOME AND WAR ABROAD.

What will be the effect of the great international struggle in Europe upon engineering undertakings proposed and in course of construction in Canada? It is difficult to predict with any guarantee of accuracy, because the present situation is unparalleled, not only in the history of Canada but also in that of the whole world. We can but analyze the situation so far as available data will allow. In the matter of works of construction the natural division seems to be as follows:

(1) Work in progress and possible of postponement.
(2) Work in progress and necessary to continue.
(3) Proposed works, capable of postponement.
(4) Proposed works, necessary to continue.
(5) New work undertaken, due to war.

Obviously, all these divisions are dependent upon successful financing. It is likely that some of the undertakings now in course of construction, and which might even be postponed without disadvantage, will proceed if the funds for the work were obtained prior to the outbreak of war. On the other hand, those enterprises which have not been financed and which, to any degree of convenience can be postponed, will undoubtedly be stopped. There are certain works which must continue, and it is probable that these have been financed completely, except unusually large undertakings, such as the Toronto Union Station, the Greater Winnipeg Water District scheme, and the Harbor Board's development at Toronto. The total cost of these and similar undertakings in each case is high. The Toronto Harbor Board raised funds by the sale, some months ago, of several million dollars worth of bonds, which will finance their work for some little time to come. The Greater Winnipeg Water District Board obtained $2,000,000 in London last month, and that sum will finance their work for some months. The railway companies interested in Toronto's Union Station probably have enough money to proceed, slowly at any rate, with the work of construction.

Works which have been proposed but which are capable of convenient postponement, will undoubtedly be delayed to some extent, if not lengthily postponed. This applies more particularly to the undertakings of private corporations. There are certain proposed works which it is highly desirable to continue, such as, for instance, certain improvements and extensions of the Ontario Hydro-Electric Commission's general scheme. Private corporations probably will not consider it justifiable, in view of events in Europe, to proceed with any extensive proposed works and which were thought perhaps to be necessary.

Some new work may be undertaken in Canada due directly to the outbreak of hostilities. This would likely be in ship-yards chiefly, in connection with naval and military operations generally, and with war engineering.

In considering these factors, we must subdivide them again into:

(1) Works of private capital.
(2) Works of government authorities.

The writer has been of opinion always that governments in times of extreme trade depression should spend money on public works, so far as proper economy dictates. In a time such as the present, and in view of the fact that the theatre of war is not actually on Canadian soil, the Dominion Government well might employ fairly substantial sums upon certain public works. Private borrowers will hesitate considerably at present because Canada's chief lender (Great Britain) has a bigger job on hand now than loaning money to its overseas dominions. Indeed, private borrowers, in which are included corporations, are almost helpless, except for funds in hand and for the possibility of borrowing elsewhere than in Great Britain.

On the other hand, the Dominion's credit is better than that of any other borrower in the Dominion, and there are several methods, such as the raising of temporary loans, which the government might use in case of necessity. The citizens of Canada likely would not protest against any action taken by the government to give employment to the citizens and to their industries, in such a time as this, any more than they will protest when the government imposes a special tax on tea and other commodities for war purposes in the British Empire.

Aside from that particular phase, the situation is regulated considerably by the fact that Great Britain, which has loaned Canada altogether £500,000,000, cannot, for the time being, continue to lend. One naturally turns to our nearest neighbor, the United States, which in its time has borrowed enormous sums of money from Great Britain, and which has in recent years become one of the two minor lending countries, the other being France, Great Britain taking first place. The United States has enjoyed for several years sixty per cent. of Canada's import trade. If the United States is able at this time to finance the immediate needs of Canada, there is a pleasing likelihood that a fairly substantial amount of construction work will proceed. This will be further emphasized if the Dominion Government, having due regard to the menace of war, will go on with a certain amount of public work.

THE QUEBEC STREAMS COMMISSION.

The second report of the Quebec Streams Commission, organized in December, 1911, has just been issued, and contains a statement of the studies of a general nature that were carried on during 1913. The personnel of the Commission consists of Chairman, S. N. Parent, C.E.; Commissioners, Ernest Bélanger, C.E., and Wm. I. Bishop, C.E.; Engineer, Olivier Lefebvre, C.E.; Secretary, H. L. de Martigny. It submits a somewhat lengthy investigation on the determination of the legal character of rivers in Quebec and their classification. Other studies are based upon the regulation of the construction of dams and other hydraulic works on these rivers, and upon the improvement of rivers for floating logs, and the authorized tolls. Still others include the regulation of the flow of the St. Francis River and its tributary, the Magog, by means of storage dams to be erected at the outlet of the principal lakes which feed them. Such a problem requires the consideration of several distinct elements, as, for instance, the general usefulness of the project, the technical difficulties to be overcome, the cost of the proposed works, the practical results, the revenue to be derived, and the methods of financing and carrying out the undertaking.

The object of the St. Francis River equalization is primarily to reduce the height of flood waters, thus minimizing the risk to bridges and other structures along the waterway, preventing overflow upon adjacent lands and minimizing present losses to lumbering operators caused by the breaking of booms, etc. It would increase the present low-water flow to approximately double the present figures, increasing the available continuous water power, and the capacity of manufacturing plants, as well as the advantages that would accrue to log driving by increasing the length of time each year for operations. Besides, the petitioners claim that the prevention of extreme low-water periods would greatly improve sanitary conditions and domestic water supplies in towns and villages along the river.

TO ESTABLISH A MERIDIAN AT ANY TIME, BY HOUR ANGLE.

By J. A. Macdonald, Ottawa, Ont.

By the peculiar and ingenious arrangement, prepared originally by Mr. J. B. Shinn, of the U.S. General Land Office, Washington, and issued by the commissioner, a new set of tables designed to enable observations for azimuth to the nearest minute to be made at any hour by an observation of Polaris is now obtainable. By the use of this table, an observation for azimuth can be made at any time when Polaris is visible. All the data necessary to make the observation are presented on two pages. Every surveyor knows how inconvenient it is to await the time of elongation of Polaris, especially in the cold, winter weather, while at times both elongations occur in the daylight hours. By means of this simple table, the observation can be taken at pleasure, simply noting the time (local mean time); the azimuth of the star may be taken out later for that particular time. The annexed diagram shows in their proper relation the various aspects of Polaris in its daily apparent motion around the North Pole.

Hour Angle of Polaris.—In the figure the full vertical line represents a portion of the meridian passing through the zenith, Z (the point directly overhead), and intersecting the northern horizon at the north point N, from which, for surveying or draughting purposes, the azimuths of Polaris are reckoned east and west. The meridian is pointed by the plumb line when it is in the same plane with the eye of the observer and Polaris on the meridian, and a visual representation is also seen in the vertical wire of the transit, when it covers the star on the meridian.

When Polaris crosses the meridian it is said to culminate; above the pole, at S, the passage is called the Upper Culmination, in contradistinction to the Lower Culmination, at S'. The engineer will better understand the diagram by holding it up perpendicular to the line of sight when he looks toward the pole—Polaris is supposed to be on the meridian, where it will be about noon on April 10th of each year. The star appears to revolve around the pole in the direction of the arrows, once in every 23 hours 56.1 minutes, mean solar time. It consequently comes to and crosses the meridian, or culminates, nearly four minutes earlier each successive day. One-quarter of the circle will be described in 5 hours 59 minutes, one-half in 11 hours 58 minutes, and three-quarters in 17 hours 57 minutes.

The hour angles of Polaris expressed in mean solar time (common clock) are counted from the upper meridian, at S, to the west, around the circle from 0 hours 0 minutes to 23 hours 56.1 minutes, and may have any value between the limits named. The hour angles measured by the arcs are 1 hour 8 minutes; 5 hours 55 minutes; 9 hours 4 minutes; 14 hours 52 minutes; 18 hours 1 minute; and 22 hours 48 minutes respectively; their extent is indicated graphically.

All the surveyor has to do, then, is to subtract the time of upper culmination (as found in the tables) from the correct local mean time of observation. The remainder will be the hour angle of Polaris expressed in

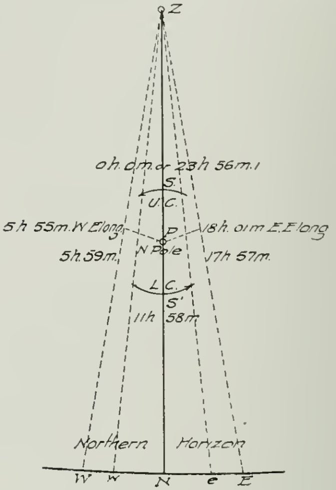


Fig. 1.

time. The table of culminations answers for all latitudes, and in general, for all longitudes, hence its simplicity. The table, Part II., answers for latitudes 30 deg. to 50 deg., and also distinctly for each year.

Example.—Required the hour angle and azimuth of Polaris for a point in latitude 41 deg. 12 minutes N, at 6 hours 16 minutes a.m., November 19th.

	h.	m.
Astronomical time of observation, Nov. 18th..	18	16.0
Astronomical time U.C. Polaris (Table, Part I.)	9	34.6
(Subtracting)	8	41.4

With this hour angle of Polaris, 8 h. 41.4 m., enter table Part II. Azimuth of Polaris at observation (Table, Part II.) 74 m. or 1 deg. 14 m. W.

These tables combine in two operations the essentials which, under ordinary methods, would require about twenty.

The watch time to be used when making observations should be as accurate as can be obtained, for to obtain the azimuth to the nearest whole minute of arc, the local mean time, upon which all depends, except for elongation, should be known within two minutes. When standard railway time is used, as probable in most cases, the observer will correct the same for difference of longitude at the rate of 4 minutes of time for each degree of difference in arc. This difference of longitude can be nearly always taken from a map. The correction will be subtracted from the standard railway time of observation when the surveyor's station is west, and added when east of the standard meridian, to obtain local time.

MINING IN QUEBEC, 1913.

A STATISTICAL review of mining operations in the Province of Quebec during the year 1913, is contained in the recent report of the mines branch of the Provincial Department of Colonization, Mines and Fisheries. According to it, the value of the products of the mines and quarries of the province reached a total of $13,119,811 during the year ending December 31st, 1913. It is the highest annual production recorded to date and exceeds that of 1912 by $1,932,701, or a proportional increase of 17%.

The Mining Law is quite explicit in respect to sending in reports of production. Article 2163 of the Quebec Mining Law states that "Every owner of mining rights, whether he mines himself or by others, and every person working mines shall, during the first ten days of January in each year, furnish a sworn statement of his operations for the past year, mentioning the quantity of mineral extracted, its value at the mine, the quantity and value of the marketable product, and the number of workmen employed, as well as a list of the names of persons killed in working the mines."

As a rule, returns are made promptly. But a few belated reports usually delay the final compilation of the figures. For this reason a preliminary statement is issued each year so as to place the statistics before the interested public at as early a date as possible. Although not quite complete, the early statistical data are sufficiently near the truth to give a very good idea of the state of the industry. This year's preliminary report, noted in brief in a preceding issue of this journal, appeared in the latter part of February. In 1913, there is a difference of 1.6% between the total of the early statement and the figures as finally compiled. In 1912, they differed by 1½%, and as a rule, the difference is less than 2%.

The table of production shows the greater proportion of the total is made up of the value of the structural materials. They make up 63%. The products of metalliferous mines enter for 7½% only in the total. It is a slight increase as compared with the previous year, 6.09%, and quite an appreciable one as compared with 1911, when the proportion was only 3.17%. This increase is due solely to the further development of old districts, for we have yet no production to record from the northern fields. That these will eventually contribute to the mineral production, there is no doubt. Promising geological and mineralogical conditions exist in the Kienawisik Lake region, whence discoveries of gold have been reported. In this connection, it may be mentioned that, in the Report of Mining Operations in the Province of Quebec for 1912, a report on the northwestern part of the Province of Quebec, by Dr. Bancroft, was published, as well as some notes on the gold discoveries at Lake Kienawisik.

The following table gives the annual value of the mineral production of the Province of Quebec for the last ten years:

Year.	Value.	Year.	Value.
1904	$ 3,023,568	1909	$ 5,552,062
1905	3,750,300	1910	7,323,281
1906	5,019,932	1911	8,679,786
1907	5,391,368	1912	11,187,110
1908	5,458,998	1913	13,119,811

We note that since 1904 there is an unbroken series of increases of each year over the preceding one. In ten years the mineral production of the province has more than quadrupled. It is especially gratifying to note that the general business depression which prevailed during the greater part of the year 1913 does not seem to have affected the mining industry in the province. Comparing the production of 1913 with that of the previous year, the Province of Quebec shows a higher proportional increase than any of the other provinces. Quebec's increase in 1913 over 1912 amounted to 17%; Ontario 12.5%; Nova Scotia 2%; British Columbia shows a decrease of 5½%.

Table of Mineral Production of the Province of Quebec During 1913.

Substances.	No. of workmen.	Salaries.	Quantities.	Value.	Value in 1912.
Asbestos, tons	2,909	$1,686,251	136,609	$3,830,504	$3,059,084
Asbestic, tons	....	....	28,473	20,346	23,358
Copper and sulphur ore, tons	292	163,997	87,550	812,899	631,963
Feldspar, tons	6	1,379	74	1,554	2,200
Gold, ozs.	25	8,335	738	14,794	19,924
Graphite, tons	73	45,195	103	9,620	50,680
Iron ore, bog, tons	....	......	......	......	......
Iron ore, titaniferous, tons	36	6,093	4,981	9,824	4,024
Kaolin, China clay	27	15,000	253	4,354	520
Magnesite	....	......	515	3,335	9,645
Mica, lbs.	270	83,533	781,648	117,038	99,463
Mineral water, gals.	21	4,587	77,313	31,728	39,854
Ochre, tons	44	19,529	5,987	40,868	32,010
Peat, tons	....	......	......	......	2,000
Phosphate, tons	5	205	360	3,506	1,640
Quartz, tons	4	800	900	2,363	418
Silver, ozs.	10	3,687	36,392	21,791	14,591
Zinc and lead ores, tons	59	35,500	335	7,370	......
Structural Materials:					
Brick, M.	1,843	590,003	159,408	1,297,592	1,284,232
Cement, bbls.	1,278	1,136,117	2,881,480	3,361,292	3,098,350
Flagstone	....	......	......	......	600
Granite	645	365,378	......	496,588	358,749
Marble	209	108,154	......	120,541	252,041
Lime, bushels	317	163,431	1,922,837	464,424	455,570
Limestone	1,414	747,418	......	1,704,207	1,363,555
Sand	171	65,966	......	405,750	170,600
Sandstone	10	370	......	5,072	......
Slate, sq.	20	12,660	1,337	6,286	8,939
Tile, drain and sewer pipe, pottery, etc.	237	138,114	......	326,165	203,100
	9,925	$5,401,702	......	$13,119,811	$11,187,110

Building construction to the extent of $2,000,000 is under way in Moose Jaw, chief among which is the $1,250,000 Government elevator.

Coast to Coast

Lethbridge, Alta.—The street railway deficit for the year at Lethbridge was estimated in January at $40.000; and for the first six months of this year, the deficit has amounted to $19.185.35.

Winnipeg, Man.—The Grain Growers' Grain Company has secured a further lease of the Manitoba grain elevator system from the Manitoba Government on practically the same terms as previously. No definite period for the renewal was specified.

Gibson, N.B.—Concrete Builders, Limited, has installed a new block tamping machine and brick attachment at its plant at Gibson, N.B. The block tamper is capable of producing 500 concrete blocks per day; and the brick attachment, of 10,000 bricks per day.

Regina, Sask.—The 5,000,000-gallon reservoir which is being built at Regina by day labor comprises an area for excavation of 250 feet by 150 feet. The soil from the excavation which will total 11,000 cubic yards when completed, is being removed to form a covering for nuisance grounds in the city north of Fourth Avenue.

Winnipeg, Man.—On many portions of that part of the C.N.R. which lies in the district west of the western boundary of Manitoba from the Great Lakes, the work of replacing the 60-pound rails on the main line with 90-pound rails, has been proceeding. It is said that before winter the company will have laid in all 300 miles of this heavy steel.

Halifax, N.S.—Building operations are quite brisk and several buildings are now under construction, the principal building being the large Acadia School, which will be a first-class structure, with the most modern improvements. There are also two schools which will have large additions attached to them. St. Joseph's Temperance Hall is well under construction.

Regina, Sask.—The city of Regina has decided to proceed at once with its programme of water main construction for 1914. The work is being done partly by day labor under the direction of the city's waterworks department, and partly by John Brodt, who is employing machines. This is being done that the department may get a comparison of prices in the work on each class of pipe, with the exception of the 24-inch pipe which amounts to only two blocks and will be laid entirely by the city.

Lacombe, Alta.—The first gasoline electric railway to be constructed in Alberta is the line now under construction from Lacombe West to Gull Lake, Bentley, and Rimbey, a distance of around 45 miles. It is reported as well under way, over half the distance being graded, and ties being on the ground the full length of the route. Moreover, the rails are in the yards, and one of the cars is now on the way from England, where it was manufactured; so that it is fully expected to have the line in operation early this fall.

Guelph, Ont.—Operations have ceased for a time on the drilling being done by Peat and Son of Petrolia, who were given the contract to bore the artesian well at the Guelph waterworks pumping station. The drill had reached a depth of 870 feet, and indications did not promise that a pure flow of water would be encountered at a lower depth. It is declared that the mineralized water which has already been struck in the city can be utilized; and it is thought that the flow will reach at least 50,000 or 60,000 gallons per day.

Toronto, Ont.—The local hydro-electric commission has recently been experimenting with "half-watt" lamps for street lighting, and the entire Avenue Road hill district and several sections of streets in other parts of the city have been furnished with these. The effect has been to produce on the Avenue Road hill twice as much light as previously. The new nitrogen or "half-watt" lamps give, when new, a radiance of some 200 candle power; while the former tungsten bulb was equal in radiance to 80 candle power.

Toronto, Ont.—The orders recently placed by the C.N.R. company for equipment were given as follows: to the Canadian Car and Foundry Co. for between 25 and 30 passenger and sleeping cars at a money value of about $500,000; to the National Steel Car Co. of Hamilton for 10 baggage cars at a cost of between $50,000 and $60,000; and to the Crossen Car Company and the Preston Car and Coach Company for smaller orders of passenger equipment. The company has not as yet placed any orders for freight equipment, and is not expected to do so for some time.

Toronto, Ont.—The most recent report upon the colonization roads work in progress in Northern Ontario announces that the Port Arthur and Fort William road is being stoned and gravelled; and new roads are being cut into the Pigeon River country, connecting Fort William with the Minnesota State road, which will run through 57 miles of new country in Canada. The State road leads to Duluth, and is 100 miles long. The Sydney to North Bay trunk road will be completed within a year, while the trunk road between North Bay and Mattawa is now finished. Early this season the Sudbury to the Soo road will be open.

Calgary, Alta.—City Commissioner Graves, of Calgary, calls attention to the announcement in our "Coast to Coast" columns of July 9th regarding the surplus for 1913 of the Calgary Electric Railway. The figures given, $177,000, presumably relate to the city electric light department, whose surplus was in the vicinity of that figure. That of the street railway was $71,627.81 at December 31st, 1913, according to the Commissioner. In regard to the deficit of $70,000, reported in our issue of July 2nd, the city authorities are not in a position to state what the outcome for the year will be, under which circumstances the figure mentioned is not justified.

Montreal, Que.—The Hon. J. A. Tessier, provincial Minister of roads, recently stated in connection with the progress that is being made on the road under construction between Levis and Jackman, Que., that already 13 miles of the road have been completed, and 30 more have been graded ready for the top macadam dressing, the present progress warranting the hope that the entire 70 miles between the two points would be finished this year. The minister also said that at present he is engaged upon plans for the new highway from Montreal to Quebec; and that the whole question of road construction in the province is advancing as never before.

Toronto, Ont.—Three years will be required to complete the proposed project for disposing of garbage in Toronto. The scheme will not only entail the construction of a new central plant, but will necessitate the construction of special cars for the conveyance of garbage; since the transit must be made along street railway lines and must be odorless. The plans also include the installing of special cans for household service, so as to make the new system thoroughly modern, clean and effective. The new method of special preparation of the garbage, and the separation of its various elements, will also make the disposal profitable. The sale of grease and fertilizer will reduce the cost of incineration; and all smell will be eliminated in the process by the deodorizing of gases.

Calgary, Alta.—The Bow Island Natural Gas and Calgary Oil Company, Limited, has altered its proposal to meet the requirements of the city of Calgary that the word "exclusive" should be cut from the franchise it seeks to make

with the city for the supply of gas at the city boundary. It will either construct a pipe line from Bow Island to the city limits and supply gas at 10 cents per 1,000 cubic feet, or sell gas at Bow Island at 2½ cents per 1,000 cubic feet, the city to construct the pipe line. The city is asked, however, to contract for a minimum amount of gas, not as yet determined; and, if this amount is exceeded, the city is to be free to continue taking its supply from the company, or if dissatisfied with the service or price, from some other company. The company has already sunk one well which is capable of producing 10,000,000 cubic feet of gas per day, and is anxious to secure a market without delay.

Porcupine, Ont.—A twenty stamp addition to the Hollinger mill has been completed, and will be running in a few weeks. Then the foundations will be laid for the twenty stamps which are to be reserved for the ore from the Acme gold mine, the private property of the syndicate. There is already enough ore on the Acme blocked out to keep them going for some time. Basing calculations upon the stamp duty of the present Hollinger mill, the combined plant will then have a capacity of over a thousand tons a day. It is not expected that the whole of the eighty stamps will be in operation until next February. The main vein of the Hollinger has been cut at the 675 feet level. It is about twelve feet wide, and appears to carry much the usual grade of ore. No. 41 vein has also been picked up on the 200-foot level, and this discovery will add considerably to the probable ore reserves of the mine. Another shaft is being sunk to open up the Hollinger property from the south.

Edmonton, Alta.—An inspection of the Alberta and Great Waterways Railway, now under construction from Edmonton to Fort McMurray, was made recently as far north as Lac La Biche by W. R. Smith, chief engineer of the line, who reports that the first 14 miles of grading is completed. Track is now completed to mile 14, at which point ballasting of the completed portion will be commenced and proceeded with with all possible despatch. Beyond mile 14, despite the handicap of an exceptionally wet season, work is progressing favorably. The completed portions of grade aggregate well over 50 miles. It is thought that the grade will reach the lake by the fall; and the intention is to rush track-laying to mile 26, where the Redwater River crossing will delay operations for a few days, while a bridge is being driven across the stream. When the bridge is completed the track-laying machine will follow the grade northward as it is made ready for the steel.

Ottawa, Ont.—A project of the United States Government to construct a waterway to connect Montreal and New York, has recently been discussed at Ottawa, the representatives from the United States in connection with the scheme being Colonel W. M. Black, of the United States army engineering corps, New York, and Lieutenant-Colonel Harry Taylor, assistant chief engineer at Washington. It is planned that the waterway will be 12 feet deep, and will go by way of the Richelieu. The present water communication is not deep enough to be very practicable. The plan was first proposed some few years ago in Canada; but after a government investigation of its possibilities, nothing was done. The scheme involves the building of a movable dam near St. John, so as to increase the level of the Richelieu River where it leaves Lake Champlain, and thus overcome the rapids around which the Chambly Canal now provides a route. A short canal to La Prairie instead of by way of Sorel is also mooted.

Montreal, Que.—Messrs. Warren and Wetmore have completed plans for the temporary passenger station which is to be erected at Montreal by the C.N.R. The structure will be a modern one of steel and concrete 150 feet front by 100 feet depth, and will have two storeys above and one below street level. From the front street, there will be seven doors leading into a vestibule 21 feet wide and 100 feet long and thence into the passenger waiting room, 60 by 100 feet and 30 feet high. This will be flanked by all the various rooms and offices customary at railroad stations. Immediately below the vestibule is the concourse with easy ramps leading to the platforms. There will be 3 double platforms and 6 tracks; and it is understood that these tracks will be permanent and will form a part of the future track system of the C.N.R. permanent terminals in this city. The baggage will be handled in a separate portion of the building in the rear approached by special driveways; and from the platforms it will be handled by lifts.

Vancouver, B.C.—Work has commenced on the wharves and slipways which constitute part of the drydock construction being undertaken by the Dominion Shipbuilding Company at Vancouver. The amount to be expended on the enterprise will be $2,500,000; and it will be a couple of years before the plant is prepared to handle ships. According to the plans of the company a big floating drydock, capable of lifting big vessels, will be built; and shops equipped to carry out the largest kind of repair jobs will be erected. The work of dredging, filling and laying out of the foundations of the buildings is being done by the British Columbia Granitoid and Contracting Co., Limited, of Seattle. The first two buildings to be erected will be the machine shop and boiler shop; and the plant of the Mainland Ironworks, of Vancouver, which has been absorbed by the new undertaking, will be moved at once to the north shore site in order that the new company will be able to proceed with this branch of the work. Lynn Creek will be dredged over an area 2,900 feet long, 100 feet wide and 25 feet deep; and all the sand and gravel taken from these dredging operations will be conveyed by suction and placed over the entire site.

Montreal, Que.—The chief features of a scheme of tunnel and terminal construction which has been devised by Napoleon Hebert, a controller of Montreal, are:—(1) a union station on the site of the present Place Viger station to accommodate passenger traffic of the Canadian Pacific, Canadian Northern, and Grand Trunk and the various lines, including the Intercolonial, that have running rights; (2) the purchase of the Bonaventure station site and the present rights-of-way as far as St. Henry, the demolition of the structures, and the removal of the tracks; (3) a provision for more freight terminal space in compensation for the expropriation of the Grand Trunk Bonaventure station, probably in St. Gabriel ward; (4) a line to provide connection with the proposed union station, opening from St. Henry, and proceeding by elevated tracks along the river-front streets; (5) the removal from the river-front of the Canadian Pacific tracks and the establishment of a new entrance to Place Viger by constructing a tunnel or subway from Mile End; (6) the removal of Moreau Street station of the Canadian Northern and the construction of a tunnel to give a new entrance to the proposed union station; (7) a provision of space in the tunnel for the Tramways Company, running northwards from Place Viger to Mile End.

Moncton, N.B.—The city council of Moncton has adopted a proposition which will be submitted to Mr. F. P. Gutelius, General Manager of Government Railways, for ratification; and, pending the agreement being satisfactory to him, a plebiscite vote will be taken on the proposition at as early a date as possible. The proposition deals with the question which has been discussed at different meetings of the city council and representatives of the I.C.R.—i.e., the elimination of level crossings in the city of Moncton; and provides for, first, the elimination of all grade crossings, save one, between Main and Union Streets; secondly, a permanent overhead bridge, 70 feet wide, at Union Street; thirdly, an overhead bridge at St. George Street, and one at Victoria Street; fourthly, a sub-

way at Main Street and a slight change in Archibald Street; fifthly, a 6-foot concrete sidewalk on railway property from Robinson Street to Main Street on the western side of the Railway; sixthly, a pedestrian subway under Lutz Street, Queen Street to remain open for 3 years or until some arrangement is reached between the railway and city council; and last, the entire programme of construction to be done by the railway, and the city to contribute $5,000 to the company upon the completion of the work.

PERSONAL.

D. ROSS has been appointed locomotive foreman in charge of work at the Southwark terminals of the Grand Trunk Railway.

J. R. ESSON, ROBT. McKAIG, and ROY ROBERTSON, of Petrolia, left last week for Mexico to carry on oil-drilling operations there.

R. H. SPERLING, general manager of the British Columbia Electric Railway Co., has resigned and is being succeeded by Mr. George Kidd.

H. H. BOYD, of Saskatoon, has taken up, at Moose Jaw, the duties of superintendent of the Moose Jaw division of the Canadian Pacific Railway.

A. N. BEER, who has been engineer in charge of the Waterworks Department of the City of Ottawa during the past year, has handed in his resignation.

M. C. McCONNELL, of the Geological Survey of Canada, is in the Omineca Mining Division of British Columbia investigating the geology of the Hudson Bay mountain.

R. H. CAMPBELL, Superintendent of Forestry, Ottawa, has been made an honorary member of the Royal Scottish Arboriculture Society at its recent conference at Edinburgh.

C. A. MEADOWS, B.A.Sc., has just returned from Europe, where he has spent three months on an investigation of improved machinery for wire and ornamental iron work.

WILLIS CHIPMAN, C.E., Consulting Engineer, Toronto, has been retained by the City of Edmonton to report upon the several electric power schemes now under consideration.

C. G. TITUS, B.A.Sc., for three years engineer and assistant manager of the Temiskaming Mines, Cobalt, Ont., has been appointed superintendent of the Renfrew Molybdenum Mines.

CHAS. GRASS, of Waasis, N.B., formerly concrete inspector on the I.C.R., has been appointed assistant bridge inspector, under Mr. Eugene Savage, on the Canada Eastern Division of the I.C.R.

WM. SNAITH, secretary-treasurer of the Thor Iron Works, Toronto, has just returned from a five months' absence in California, where he was superintending for his company the construction of a number of large oil tanks at Oilfields, Cal.

FRANK SCOTT, of Montreal, treasurer of the Grand Trunk Railway for 13 years, and of the Grand Trunk Pacific since 1906, has been appointed the vice-president and treasurer of the company, a new position occasioned by the death of Mr. M. M. Reynolds, formerly vice-president.

S. NAKAGAMI, vice-councillor of the Imperial Government Railways of Japan, arrived in Canada from Tokio last week and will remain in this country for several months investigating its railway systems. Interviewed in Montreal, Mr. Nakagami stated that Japan had now about 6,000 mi. of railway in addition to several new lines under construction and others in contemplation. It is in connection with this contemplated work that the present visit of Mr. Nakagami is involved.

OBITUARY.

The death occurred in Victoria, B.C., recently of Mr. John Niblock, a prominent railroad man in Western Canada. Mr. Niblock, born near Toronto in 1849, entered the service of the Canadian Pacific Railway in its early days and was train-master at Winnipeg for a number of years. Later he was placed in charge of the shops at Medicine Hat. Afterwards he was superintendent of the C.P.R. from Swift Current to Laggan.

PEAT CONVENTION AT DULUTH.

The American Peat Society will hold its eighth annual meeting in Duluth, Minn., August 20th, 21st and 22nd. Important papers on the peat industry, peat lands, and the use of peat for fuel will be presented by numerous investigators and experts from various countries. There will also be an exhibition of peat, peat products, and machinery and apparatus for its preparation and development.

ASSOCIATION OF RAILROAD SUPERINTENDENTS.

The twenty-seventh annual meeting of the American Association of Railroad Superintendents is to be held in New York City on August 20th and 21st, at the Hotel Woodward.

COMING MEETINGS.

WESTERN CANADA IRRIGATION ASSOCIATION.—Eighth Annual Meeting to be held at Penticton, B.C., on August 17, 18 and 19. Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

AMERICAN PEAT SOCIETY.—Eight Annual Meeting will be held in Duluth, Minn., on August 20th, 21st and 22nd, 1914. Secretary-Treasurer, Julius Bordollo, 17 Battery Place, New York, N.Y.

CANADIAN FORESTRY ASSOCIATION.—Annual Convention to be held in Halifax, N.S., September 1st to 4th, 1914. Secretary, James Lawler, Journal Building, Ottawa.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Secretary, Will P. Blair, 832 B. of L.E. Building, Cleveland, Ohio. Eleventh annual convention and paving conference, Buffalo, N.Y., September 9th, 10th, 11th, 1914.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown, Indianapolis, Ind., Secretary.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.—11th Annual Convention; 5th American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau St., New York, N.Y.

Volume 27. Toronto, August 20, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

SURGE TANK PROBLEMS

AN INVESTIGATION OF SURGE TANK REGULATION DETERMINING BY GRAPHICAL AND ANALYTICAL METHODS PROPER SOLUTIONS OF PROBLEMS CREATED BY LONG PIPE LINES.

By PROF. FRANZ PRASIL,

Authorized Translation by E. R. Weinmann and D. R. Cooper, Hydraulic Engineers, New York City.

PART I.

IN case the main conduit leading to a turbine is comparatively long, beginning at the intake on a comparatively light slope (canal, tunnel or low-pressure pipe) and concluding in a short steep slope leading directly to the turbines, (high-pressure pipe or penstock), it is common practice to construct at the junction an open tank, called the surge tank, by which the main conduit is separated into two parts, in which with a constant discharge of the turbines the flow in the conduit is constant, and with a variable turbine discharge a variable conduit flow results. In the first case, the water surface in the surge tank is lower than the water surface at the intake by an amount dependent upon the flow in the low-pressure pipe. This difference of head is determined by the friction head in the main conduit. In an increment of time just as much water flows into the surge tank as flows out of it through the penstocks to the turbines.

In the second case, the inertia of the moving mass in the main conduit prevents this equality of inflow and outflow. The water surface in the surge tank has variable heights, that is, it rises or falls above and below the elevation due to the steady flow. The extent of this fluctuation of the water surface depends upon the dimensions of the main conduit, the amount of flow, and also on the size and form of the surge tank. In this case, if an overflow or an excessive lowering or too large fluctuations of the water surface are to be prevented, the surge tank must be dimensioned according to the area and length of the main conduit and according to the inflow and outflow. In this article the problems leading to the determination of the dimensions will be discussed, and the methods, partly analytical and partly graphical, involved in the solution of these problems, will be developed upon the assumption that the main conduit from the intake to the surge tank consists of a pipe or tunnel running full under pressure.

I. Introduction.

The investigation is developed (see Fig. 1) under the following additional assumptions:

(1) The intake is provided with a spillway whose dimensions are such that the elevation $n-n$ in the forebay may be considered as constant during the period under investigation.

(2) The sectional area of the main conduit is constant

(3) The volume of the conduit, compared to the volume of the surge tank and compared to that part of the volume of the forebay which is affected, is so large that the influence of both of these masses of water toward decreasing the flow may be neglected.

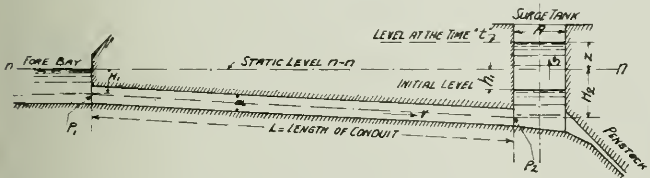


Fig. 1.

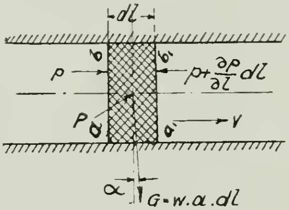


Fig. 2.

(4) Elastic and temperature conditions are neglected.

In the derivations of the formulæ, the following abbreviations are used:

L = Length of main conduit in feet.

a = Sectional area of main conduit in square feet.

p = Wetted perimeter of main conduit in feet.

v = Velocity of water in main conduit in feet per second at the time "t".

v_1 = Normal velocity of water in the main conduit in feet per second, during the period of steady flow.

v_2 = Initial velocity in the main conduit in feet per second, at the time $t = o$.

(v, v_1 and v_2 are average values and are assumed as constant throughout the entire length of the main conduit).

H_1 = Vertical distance from the water surface $n-n$ in the forebay to the centre of gravity of the entrance to the main conduit.

H_2 = Vertical distance from the water surface $n-n$ in the forebay to the centre of gravity of the entrance to the surge tank.

Q, Q_1, Q_2 = Volumes of water, corresponding to time t, the time during steady flow, and for time $t = o$ (beginning).

h, h_1 and h_2 = Friction heads corresponding to the pipe dimensions and velocities v, v_1 and v_2.

z = Vertical distance from the elevation $n-n$, of the water surface in the surge tank at the time t, taken positive above $n-n$ and negative below $n-n$.

A = Sectional area of surge tank in square feet for the elevation determined by z, so that in general A is a function of z.

s = Velocity of the water surface elevation in the surge tank, positive when rising, negative when falling, as an average value assumed constant in the section A.

q = Volume of discharge through the penstock at the time t, in cubic feet per second.

$c = \dfrac{q}{A}$ = the discharge velocity of the volume q, in feet per second, with respect to A.

More notations will be introduced during the course of the investigations.

II. Derivation of Principal Equations.—Referring to Fig. 2, the distance between two adjacent cross-sections of the main conduit $= dl$, and therefore $\dfrac{w.a.dl}{g}$ = mass of the water between the two sections (w = weight of cubic unit of water, g = acceleration due to gravity).

At the left side cross-section at the time t, there exists the pressure p in pounds per square foot, an average value, assumed constant for the entire cross-section. In the right, the pressure is p' at the same time t. The whole of p' is in general different from that of p, by the amount dp. The pressure p is a function of the location of the cross-section, that is to say, depends upon l; (l = the distance of the left side cross-section from the entrance of the main conduit) and depends further upon the time t (the flow varies with the time).

$$dp = \frac{\delta p}{\delta l} dl + \frac{\delta p}{\delta t} .dt \quad - \quad - \quad (1)$$

Since p and p' occur at the same time, p' is different from p by the difference due to the distance between the cross-sections, and therefore in the foregoing formula the differential dt of the time $= o$. Therefore, $dp = \dfrac{\delta p}{\delta l}.dl$ (2).

The following forces act upon an element of unit mass, in the direction of flow, that is, in the direction of v:

1st. The weight component $P_1 = w.a.dl \sin \alpha$ (3) where α = the inclination of the axis of the main conduit from the horizontal, $dl.\sin \alpha = dH$ = vertical distance between the centres of gravity of the sections $a\,b$ and $a_1\,b_1$.

$$P_1 = w.a.dH \quad - \quad - \quad (4)$$

2nd. The difference between the reactions due to the pressure p and $p + \dfrac{\delta p}{\delta l}.dl$ which is

$$P_2 = p.a - \left(p + \frac{\delta p}{\delta l}.dl\right) a = - a \frac{\delta p}{\delta l} dl \quad - \quad (5)$$

Contrary to the direction of motion the friction exerts a force. Let K be the amount of the friction in terms of the velocity v and we get $P = - wa.dl.K$ (6) where K represents a pure number with respect to its dimension.

According to the general fundamental law: mass × acceleration = acting force, it results (as $\dfrac{dv}{dt}$ is the acceleration with respect to the velocity v at the time t) that,

$$m.\frac{dv}{dt} = P_1 + P_2 - P \quad - \quad - \quad - \quad - \quad (7)$$

$$\frac{dv}{dt} \times \frac{w.a.dl}{g} = w.a.dH - a \frac{\delta p}{\delta l} dl - w.a\, dl.K \quad (8)$$

$$\frac{dl}{g} . \frac{dv}{dt} = dH - \frac{1}{w} \frac{\delta p}{\delta l} dl - K\,dl \quad - \quad - \quad (9)$$

The velocity v has the same value at the time t in the whole length of the main conduit. ~~The case is therefore the same~~ So also have for $\dfrac{dv}{dt}$ and K. Therefore, if we integrate between the limiting values $l = o$ and $l = L$ or $H = H_1$ and $H = H_2$ relative to a motion from the intake to the main conduit, we get the following:

$$\frac{L}{g}.\frac{dv}{dt} = H_2 - H_1 - \frac{1}{w} \int_0^L \frac{\delta p}{\delta l} dl - KL \qquad (10)$$

In the integral $\displaystyle\int_0^L \frac{\delta p}{\delta l} . dl$, p is, as demonstrated, a function of t and l. But as the integration relates to the condition at a certain time t, t is to be considered as a constant and therefore

$$\int_0^L \frac{\delta p}{\delta l} dl = p_2 - p_1 \quad - \quad - \quad (11)$$

where p_2 = pressure at the entrance to the surge tank p_1 at the entrance to the main conduit, KL is nothing other than the friction head h for the entire main conduit at the time t. Now, we may say that

$$\frac{p_2}{w} = H_2 + z + \frac{p_0}{w}; \quad \frac{p_1}{w} = H_1 + \frac{p_0}{w} \qquad (12)$$

in which $\dfrac{p_0}{w}$ equals the water column equivalent to the atmospheric pressure, and the following equation results:

$$\frac{L}{g} . \frac{dv}{dt} + z + h = o \quad - \quad - \quad (13)$$

Having assumed a flow in the main conduit from the intake to the surge tank, we consider now the flow as reversed (from the surge tank to the intake) and keep the direction for the measurement of the length l the same, then we must consider that the friction now acts in the

direction of an increase of l, contrary to the first instance. In this case we get the equation

$$\frac{L}{g}\frac{dv}{dt} + z - h = o \qquad (14)$$

For any case we may combine both equations into a fundamental formula:

$$\frac{L}{g} \cdot \frac{dv}{dt} + z \pm h = o \qquad (15)$$

in which the plus refers to the velocity from intake to surge tank and the minus sign for the reverse movement. If we now introduce for h a function, the value of which has the same sign as v, then the double sign may be dropped and the whole movement may be represented by the equation:

$$\frac{L}{g} \cdot \frac{dv}{dt} + z + h = o \qquad (16)$$

A second fundamental equation may be developed from the condition of continuous flow, that is to say, the volume of water which flows to the surge tank in the time element dt must be equal to the sum of the changes of volume in the surge tank and in the volume flowing out of the tank at the same time ∴

$$v.a.dt = s\,A\,dt + q.dt.$$

$$a.v = As + q = A(s + c) \qquad (17)$$

The questions which are of principal interest are:

1st. How is the movement of the water surface in the surge tank with regard to time affected by given dimensions of the main conduit and the surge tank and given conditions as to overflow?

2nd. What dimensions must the surge tank have to agree with given conditions as to the main conduit and outflow, in order that the fluctuation of water level does not exceed certain amounts, determined by local conditions? The following cases will be investigated:

(a) Sudden partial or entire cessation of the outflow.

(b) Sudden starting of the outflow.

(c) Gradual cessation, or starting, variable outflowing conditions; and

(d) Influence of a spillway built in the surge tank.

The formulæ will be developed in the first case for a constant sectional area of surge tank, and under the assumption that h is proportional to v, i.e., $h = n.v$.

It will be shown that it is possible to investigate all cases according to a uniform method, analytically and graphically, with the assistance of the well-known theory of damped and forced undulations. The inaccuracies which result because h is proportional to v^2 and the corrections which must be applied to the results of the first method will be shown in the final study. With the simplifying assumptions already mentioned, we get from equation (17)

$$v = \frac{A}{a}(s + c) \qquad \frac{dv}{dt} = \frac{A}{a}\left(\frac{ds}{dt} + \frac{dc}{dt}\right) \qquad (18)$$

This applied in equation (16) and the whole equation divided by

$$T^2 = \frac{L}{g} \cdot \frac{A}{a} \text{ (19), we get } \frac{ds}{dt} + \frac{dc}{dt} + \frac{z}{T^2} + \frac{h}{T^2} =$$

$$\frac{ds}{dt} + \frac{n.A}{T^2 .\, a} \cdot s + \frac{z}{T^2} + \frac{n\,A}{T^2 a} \cdot c + \frac{dc}{dt} = o \qquad (20)$$

If we introduce as an abbreviation:

$$T_o = \frac{T^2 .\, a}{n\,.\,A} \qquad (21)$$

and consider that

$$s = \frac{dz}{dt} \qquad \frac{ds}{dt} = \frac{d^2z}{dt^2} \qquad (22)$$

then follows the principal equation:

$$\frac{d^2z}{dt^2} + \frac{1}{T_o} \cdot \frac{dz}{dt} + \frac{z}{T^2} + \frac{c}{T_o} + \frac{dc}{dt} = o \qquad (23)$$

The values n and $T = \sqrt{\frac{A\,L}{a.g}}$

$$\text{and } T_o = \frac{T^2}{n} \cdot \frac{a}{A} = \frac{L}{n.g} \qquad (24)$$

are times with regard to their dimensions. Starting with this principal equation, we may investigate the different cases as follows:

III. Special Cases.

Case A.—Sudden Shut-down.

Preceding a shut-down, Q_1 cubic feet per second flows out of the surge tank. During the normal condition in the main conduit, the velocity $= v_1 = \frac{Q_1}{a}$ wherefore $q = Q_1$. The water surface in the surge tank is h_1 feet lower than the static level $n - n$. The time t is measured from the beginning of the shut-down, therefore from $t = 0$, q becomes ϵq if ϵ is the proportion of the steady flow subsequent to the shut-down in relation to the flow preceding the shut-down.

After the sudden shut-down, the following phenomena occur in the surge tank: The water surface rises with variable velocity until it reaches a maximum height. When the highest elevation is reached, the reverse movement occurs. The velocity increases as the water level recedes, then decreases until the lowest level is reached, after which an ascending movement occurs but to a somewhat less height than before, and so on, until the normal conditions with the constant flow $\epsilon . Q_1$ become established. The movement of the water level belongs in the category of the damped oscillations.

(1) Analytical Investigation.—The formula (23) for this case, under the condition that

$$c = \frac{q}{A} = \frac{\epsilon\,Q_1}{A} = \epsilon\,c_1 = \text{a constant } \left(\frac{dc}{dt} = o\right) \qquad (25)$$

becomes

$$\frac{d^2z}{dt^2} + \frac{1}{T_o}\frac{dz}{dt} + \frac{z}{T^2} + \epsilon\frac{c_1}{T_o} = o \qquad (26)$$

Since $h_1 = n.v_1 = n\,c_1\,\frac{A}{a} = c_1\,\frac{T^2}{T_o}$, it follows that

$$\frac{\epsilon c_1}{T_0} = \frac{\epsilon h_1}{T^2} \qquad (27)$$

If we introduce $z = y - \epsilon h_1$, therefore $\frac{dz}{dt} = \frac{dy}{dt}$;

$$\frac{d^2z}{dt^2} = \frac{d^2y}{dt^2} \quad - \quad - \qquad (28)$$

from (26) follows a differential equation of the second order

$$\frac{d^2y}{dt^2} + \frac{1}{T_0} \cdot \frac{dy}{dt} + \frac{y}{T^2} = 0 \quad - \qquad (29)$$

This is a linear differential equation of the second order with constant coefficients. For the solution we say:

$$r^2 + \frac{1}{T_0} r + \frac{1}{T^2} = 0$$

The solution of this quadratic equation will give us the values of the differential equation:

$$r = -\frac{1}{2\,T_0} \pm \sqrt{\frac{1}{(2T_0)^2} - \frac{1}{T^2}}$$

We know that according to the theory of the linear differential equations three solutions may be found.

If the radical is positive or zero, the solution of the differential equation represents a non-periodical function, that is:

$$y = R_1 . e^{-\frac{t}{2\,T_0}} + R_2\, t\, e^{-\frac{t}{2\,T_0}}$$

$$\text{if } \frac{1}{T_1^2} = \frac{1}{T^2} - \frac{1}{(2\,T_0)^2} = 0 \quad (30a)$$

$$y = (R_1\, e^{+\frac{t}{T_1}} + R_2\, e^{-\frac{t}{T_1}})\, e^{-\frac{t}{2\,T_0}}$$

$$\text{if } \frac{1}{T_1^2} = \frac{1}{T^2} - \frac{1}{(2\,T_0)^2} = \text{negative} \quad (30b)$$

But,

$$y = R\, e^{-\frac{t}{2\,T_0}} . \sin(\beta + t/T_1)$$

$$\text{if } \frac{1}{T_1^2} = \frac{1}{T^2} - \frac{1}{(2\,T_0)^2} = \text{positive} \quad (30c)$$

represents a damped harmonic.

These three conditions, due to the different values of the radical of the quadratic equation can be written also, substituting for T and T_0 the values of equations 24:

$\frac{1}{T_1^2}$ becomes zero if $T = 2\,T_0$ or $\frac{A}{a} = \frac{4\,L}{n^2 g}$ (31a)

$\frac{1}{T_1^2}$ becomes negative if $T > 2T_0$ or $\frac{A}{a} > \frac{4\,L}{n^2 g}$ (31b)

$\frac{1}{T_1^2}$ becomes positive if $T < 2T_0$ or $\frac{A}{a} < \frac{4\,L}{n^2 g}$ (31c)

As mentioned before, equations 30a and 30b, with the conditions of 31a and 31b, represent non-periodical function, that is:

Form 1 is the expression for a damped oscillation;

Forms 2 and 3 represent non-periodical movements, i.e., a transition from one quiescent level to another without any oscillations.

As will be seen later from an example, n has in most cases a value which lies between 2 and 1 seconds; therefore, the condition for a non-periodic water level fluctuation is:

$\frac{A}{a}$ is equal to or greater than $\frac{L}{35}$.

Now, for $L = x$ miles

A should be equal to or greater than $150 . x . a$.

This case may well occur when a pond is used as the surge tank. With artificially constructed surge tanks $\frac{A}{a}$ is considerably smaller; the following investigations are therefore limited to the first form of oscillations. As $z = y - \epsilon h_1$, equation (30) may be written

$$z = -\epsilon h_1 + R\, e^{-\frac{t}{2\,T_0}} \sin(\beta + t/T_1) \quad - \quad (32)$$

and the differentiation with respect to t gives (since $\frac{dz}{dt} = s$)

$$s = R e^{-\frac{t}{2\,T_0}} \frac{1}{2\,T_0} \left\{ \frac{2\,T_0}{T_1} \cos(\beta + t/T_1) - \sin(\beta + t/T_1) \right\} (33)$$

If we substitute $tg\gamma = \frac{2\,T_0}{T_1}$ and consider that

$$\frac{1}{T_1^2} = \frac{1}{T^2} - \frac{1}{4\,T_0^2} \quad - \quad - \qquad (34)$$

we get:

$$s = \frac{R}{T} . e^{-\frac{t}{2\,T_0}} \sin(\gamma - \beta - t/T_1) \qquad (35)$$

and the integration constants R and β are determined from the initial conditions, i.e., from the location and the condition of movement of the water level in the surge tank at the time $t = 0$.

It will be noted from the description of the phenomena for that case that for the shut-down and in the very moment of it, the water surface is at the distance h_1 under the elevation $n - n$. Therefore, for $t = 0$, $z = z_0 = -h_1$. The initial value for $s = s_0$ at the time $t = 0$, must be assumed as

$$s_0 = \frac{Q_1 - \epsilon\, Q_1}{A} = (1 - \epsilon)\, c_1 \quad - \qquad (36)$$

This assumption does not only consider a sudden shut-down, but assumes also a sudden beginning of a

uniformly distributed velocity in the water surface of surge tank. This assumption is true for the limiting cases because a short duration of the shut-down does not appreciably affect the results, as we shall see from the investigation of the influence of a shut-down of short duration. Here follow the equations for the determination of the integration constant when $t = o$:

$$R \sin \beta = -(1 - \epsilon)\, h_1 \qquad (37)$$

$$R \sin (\gamma - \beta) = +(1 - \epsilon)\, c_1 T \qquad (38)$$

The latter equation may be transformed to:

$$R \cos \beta = (1 - \epsilon)\left[\frac{T_0}{T^2} - \frac{1}{2\,T_0}\right] h_1\, T_1 \qquad (39)$$

By introducing the values in the bracketed term, we find that this term is proportional to the difference

$$\left(\frac{a}{A} - \frac{n^2 g}{2\,L}\right) \qquad (40)$$

The difference is therefore positive if $\frac{A}{a}$ is less than $\frac{2\,L}{n^2 g}$, i.e., with the same assumptions for n and g as before:

$$A < 17.5.x.a$$

This has influence on the determination of the value of β, as in the case mentioned $\sin \beta$ is negative and with $\frac{A}{a} < \frac{2\,L}{n^2 g}$ the $\cos \beta$ becomes positive, i.e., β must lie in the fourth quadrant. If $\frac{4\,L}{n^2 g} > \frac{A}{a} > \frac{2\,L}{n^2 g}$, the bracketed expression and $\therefore \cos \beta$ must be negative, β lies in the third quadrant. For the last formula, we may find for the determination of R and β the equations:

$$R = (1 - \epsilon)\, h_1 \frac{T_1\, T_0}{T^2} \qquad (41)$$

$$tg\beta = -\frac{1}{T_0/T_1 - \frac{1}{4}\, T_1/T_0} \qquad (42)$$

41 is obtained by addition of the squared equations 37 and 39;

42 is the quotient of $\frac{\text{equation } 37}{\text{equation } 39}$

We see that the amount of shut-down has influence on the size of R, but not on the size of β. With respect to the occurrence of the movements (see equations 32 and 35) we find that the movement is a damped oscillation with a duration of δ secs $= 2\,\pi\, T_1$.

Maximum and minimum values of z or y occur when $\frac{dz}{dt} = o$.

This is the case when $\sin (\gamma - \beta - t/T_1) = o$. See Equation 35.

$$\frac{t}{T_1} = \gamma - \beta = \gamma - \beta + \pi = \gamma - \beta + 2\pi = \text{etc.} \qquad (43)$$

This value used for equation 32 gives the following maximum values:

$$z\ \max_1 = -\epsilon h_1 + Re^{-\frac{T_1}{2\,T_0}(\gamma - \beta)} \sin \gamma$$

$$z\ \max_2 = -\epsilon h_1 + Re^{-\frac{T_1}{2\,T_0}(\gamma - \beta + 2\pi)} \sin \gamma, \text{ etc.} \qquad (44)$$

and the following minimum values:

$$z\ \min_1 = -\epsilon h_1 - Re^{-\frac{T_1}{2\,T_0}(\gamma - \beta + \pi)} \sin \gamma$$

$$z\ \min_2 = -\epsilon h_1 - Re^{-\frac{T_1}{2\,T_0}(\gamma - \beta + 3\,\pi)} \sin \gamma, \text{ etc.} \qquad (45)$$

Due to $z = y - \epsilon h_1$

$$\frac{y\ \max_2}{y\ \max_1} = \frac{y\ \max_3}{y\ \max_2} = \ldots\ldots\ldots$$

$$= e^{-\frac{T_1}{2\,T_0}.2\pi} = \frac{y\ \min_2}{y\ \min_1} = \frac{y\ \min_3}{y\ \min_2} = \ldots. \qquad (46)$$

The amplitude of this oscillatory motion is decreasing.

If t = infin. z becomes $-\epsilon h_1$
s becomes zero

(To be continued.)

STRENGTHENING THE FORTH BRIDGE.

When the Forth Bridge was designed, 32 years ago, the loads and the train speeds calculated for were considerably in excess of those then assumed as probable for a long period, but the advance in these respects, particularly in the weight and power of locomotives and the loads behind them, has been enormous. Therefore, although the limits have not yet been reached so far as the strength of the bridge is concerned, the directors of the Forth Bridge Company have decided further to anticipate the developments of the locomotive engineer, and to reconstruct part of the flooring and troughs in which the railway track is laid over the bridge. It has been decided at once to proceed with a trial section, to be followed by a reconstruction from end to end of the bridge. The directors have arranged for the carrying out of the work by the original builders, Sir William Arrol and Co., Limited, Glasgow, and Messrs. Baker and Hurtzig will be the engineers, in association with the engineer-in-chief of the North British Railway Company, Mr. W. A. Fraser.

It is estimated that 2,500 tons of structural steel will be required for the renewal of troughs and floor from end to end of the bridge; of this total, the addition to the weight of the present steelwork of the bridge is only 750 tons. The work will take some years to execute, as operations can only be carried on during summer months, and it is proposed not to interfere with traffic on week-days, while even on Sundays one line only will be closed.

TIME OF SETTING CEMENT.

It was pointed out by Mr. S. M. Williams, in a paper read before the American Society for Testing Materials, that the factors accountable for the variable results obtained in the time of cement setting make a marked difference in the laboratory results. His paper summed up the results of considerable investigation throughout which the various influences were properly controlled and recognized. The following factors are enumerated as likely to cause errors of considerable magnitude.

1. Variation in the amount of work done on the material may cause a difference of more than two hours in the time of initial setting and cause a normal cement to appear quick setting;

2. Variation in atmospheric moisture or humidity of storage during the setting period may cause the inital time of setting to vary as much as two hours;

3. Variation in atmospheric heat or temperature of storage during the setting period may vary the time of setting as much as 1 or 2 hours.

The determination is also affected, to a less extent, by factors peculiar to the Vicat and Gillmore methods.

Throughout this series of determinations an attempt was made to keep all conditions uniform except the one whose effect was to be noted. In practice, the results obtained on two consecutive days may be affected by several factors which might combine to increase or decrease the range of values. For instance, a cool, damp day may be followed by a warmer day with a high relative humidity. The two factors on the first day both tend to retard the setting of the cement, while the high temperature of the second day, tending to shorten the time of setting, is opposed by the high humidity which reduces the amount of evaporation. To avoid the effects of these variables requires the use of a storage closet whose temperature and humidity can be controlled.

The variation in time of setting as determined by the same observer, thereby eliminating all errors due to personal equation introduced by several observers, is clearly shown, and indicates that neither method will give results consistent enough to justify the reporting of results within the limits of a few minutes.

The other variables, such as formation of the test specimen and manipulation of apparatus, are of smaller importance, compared with those of mixing and curing, but these errors may combine to increase those caused by the above.

The results obtained by varying the amount of work indicate that the test, as made at present, can be relied upon only to identify normal or slow-setting cements. The necessity for vigorous working in order that a normal cement may not be judged quick setting, defeats the object of the test when it is applied to a very quicksetting material, and may cause the set to be broken.

A study of the results makes it evident that neither the Gillmore or Vicat methods can be relied upon to give uniform results unless all factors which influence the rate of hardening are taken into account and controlled, and they further explain why comparative tests in a number of laboratories upon the same material have been found to give most variable, non-dependable results, cement often being adjudged quick-setting in one laboratory and slow-setting in another.

The British Columbia Manufacturers' Association will hold its annual convention in Victoria, September 22 and 23. One of the chief subjects proposed for discussion is "Transportation."

CHARACTERISTICS OF SAFE DRINKING WATER.*

By Dr. Allan J. McLaughlin,
Chief Sanitary Engineer and Director of Field Work, International Joint Commission.

Cities using sewage-polluted water without purification invariably have very high typhoid fever rates. The installation of a filtration plant to purify the polluted water supply almost without exception effects a prompt and remarkable reduction in the typhoid fever rate. This reduction is usually so great that municipal officials are satisfied that their water supply is perfect, when in reality there is still something to be desired. When a city with typhoid fever rates consistently above 100 deaths per 100,000 population has a reduction coincident with the installation of a filtration plant to a rate between 20 and 30, there is good ground for general rejoicing because of the undeniable saving of human lives. Nevertheless, the raw water may be of such a character that an unreasonable burden is imposed on the filtration plant, and under such circumstances, in spite of fair efficiency, the plant delivers an effluent which is unsafe at times.

With the general sanitary conditions which pertain in American cities and a safe public water supply, there is no valid excuse for typhoid rates above 20 deaths per 100,000 population. There is excellent evidence to show that if all the water-borne typhoid were eliminated in northern cities the rate for typhoid fever would be less than 10. As a matter of fact, there is a group of American cities which is fast approaching European cities in the matter of low typhoid fever rates. These are the cities which have gone farthest in making their water supply safe, and while their yearly typhoid fever rates are not always expressed in a single figure, their rates are usually below 12. In these cities with safe water supplies the general sanitary conditions, exclusive of water supply, are not conspicuously better and in some instances are very much worse than those found in cities with polluted water supplies and high typhoid fever rates.

There is a large group of cities in which, following the substitution of a filtered for a polluted public water supply, the rates have been greatly reduced but still remain too high. These cities should not be satisfied with typhoid fever rates of from 15 to 30, but it behooves them to make a searching investigation to determine whether the raw water imposes an unreasonable burden on their filtration plant, or if their plant is efficiently operated and delivering a safe water at all times.

This brings us to the question of what is safe dringing water? In order to say that a drinking water is hygienically safe one must be assured that it contains no pathogenic bacteria. The efficiency of water purification plants varies from day to day and from hour to hour, and an opinion upon the absolute safety of a given water supply can not be rendered unless many bacteriologic analyses, made at short intervals during each 24 hours, show an absence of B. coli. While an absolute dictum is thus most difficult to secure, it is not difficult by daily bacteriologic analysis to determine that a water does or does not give a reasonable index of safety. Instead of attempting to find the germs of typhoid fever, Asiatic cholera, and dysentery in water, we accept the presence of B. coli as an index of pollution with sewage, for the reason that the chances of finding B. coli are very much

*Presented at a conference of the International Joint Commission at New York City, May 26 and 27, 1914.

better than the chances of finding the specific germs in the small quantity of water examined.

When we consider the grossly polluted water supplies used by many of our large cities until recent years, we must admit that even if the present effluents from filter plants do not show constant absence of B. coli, still they must be classed as reasonably safe, or relatively safe water.

In order to secure statistics from some of our largest filtration and purification plants a circular letter was sent out to about 40 cities. About 15 responded, and in most instances the statistics covered at least one year. The list included mechanical or "rapid" sand filtration, slow sand filtration, precipitation and disinfection, and disinfection alone.

Table I. shows the average number of B. coli per 100 c.c. in both raw water and filtered or treated water.

Table I.

City.	Number of samples.	Type of filtration.	B. coli per 100 c.c. of— Raw water.	Filtered or treated water.
Toledo, Ohio	342	Mechanical filtration.	804	0.02
Minneapolis, Minn..	418	do	75	.1
Grand Rapids, Mich.	365	do	92	.3
Birmingham, Ala. ..	205	do	196	1.0
	174	do	400	.2
Cincinnati, Ohio ...	240	do	1,175	1.4
Binghamton, N.Y. .	420	do	59	1.2
Columbus, Ohio ...	365	do	606	1.3
Washington, D.C.	348	Slow sand	2,501	1.4
Providence, R.I....	600	do	732	4.3
Reading, Pa.	138	do	68	5.8
Baltimore, Md.	306	Alum and hypochlorite.	1,349	2.5
Richmond, Va.	237	do	460	8.0

Some of the results are of special interest, and the statistics for these cities are presented by months.

Toledo, Ohio.—The Toledo plant is of the mechanical-gravity type. Hypochlorite is applied to the raw water before sedimentation in quantities of 15 to 30 pounds per 1,000,000 gallons. Then aluminum sulphate is used as a coagulant.

Table II. shows the results by months in Toledo.

Table II.

Season.	Number of days' samples.	Average B. coli per 100 c. c. of— Raw water.	Filtered water.
1913—			
January	25	1,848	0
February	26	145	0
March	26	2,238	.3
April	30	1,105	0
May	29	1,270	0
June	28	67	0
July	27	300	0
August	11	600	0
September	30	280	0
October	29	286	0
November	27	766	0
December	23	530	0
1914—			
March	31	1,000	0
January, 1913, to March, 1914	342	804	.029

The Toledo plant, by the use of heroic doses of hypochlorite, is able to convert a bad raw water into a safe effluent, but in spite of this fact the necessity for constant efficiency in treating such a raw water every hour in every day from January to June places an unreasonable responsibility on the plant. From June to October a fair raw water is furnished. In November and December the B. coli per 100 c.c. in raw water was again too high.

Minneapolis, Minn.—Excellent results are also obtained in Minneapolis by a mechanical or rapid sand filtration plant. Minneapolis differs from Toledo in that the hypochlorite is applied to the filtered water and not to the raw water in quantities of three-tenths to four-tenths parts per million available chlorine. The raw water at Minneapolis is very much better than that of Toledo.

Table III. gives the average number of B. coli per 100 c. c. in both raw and filtered water by months in Minneapolis.

Table III.

Season.	Number of days' samples.	Average B. coli per 100 c. c. of— Raw water.	Filtered water.
1913—			
February	26	23	0.7
March	31	39	0
April	30	8	.3
May	29	44	0
June	30	25	0
July	31	73	0
August	31	85	.6
September	30	79	0
October	31	53	0
November	30	85	0
December	30	100	0
1914—			
January	30	100	0
February	28	90	.3
March	31	242	.6
February, 1913, to March, 1914	418	75	.19

Cincinnati, Ohio.—The Cincinnati plant utilizes plain sedimentation followed by coagulation and mechanical filtration. Sulphate of iron and caustic lime are used, the latter to assist the action of the iron sulphate and not for softening purposes. Hypochlorite is added to the filtered water for about five months in the year. About 1 pound is used to each million gallons of water. Hypochlorite is used during January, February, March, April, and May, which covers the period of muddy water and high bacterial counts.

Table IV.

Season	Number of days' samples.	Average B. coli per 100 c.c. of Raw water.	Filtered water without "hypo."	With "hypo."
1913—				
September	28	964	2.1	...
October	31	358	1.5	...
November	30	1,990	2.7	...
December	31	1,841	3.0	...
1914—				
January	31	1,232	9.1	0.6
February	28	1,260	3.5	1.2
March	31	825	2.4	.06
April	30	933	20.0	.4
Sept., 1913, to April, 1914 ..	240	1,175	5.6	1.4

The results are very interesting. A bad raw water which threatens to overtax the purifying capacity of the filters is successfully handled by the use of hypochlorite as an auxiliary. The results shown in Table IV. indicate that in January, February, March, and especially April, 1914, the plant without the aid of "hypo" was unable to successfully cope with the bad raw water. With the aid of "hypo" a good effluent was secured.

Columbus, Ohio.—At the mechanical filtration plant of Columbus, Ohio, lime, soda ash, and aluminum sulphate are used. Hypochlorite is occasionally used applied to the settled water before filtration. Table V. gives results by months for the year 1913. With a bad raw water excellent results are obtained. Mr. Hoover, the chemist in charge, attributes these results to the free use of lime. This seems probable as very little hypochlorite is used.

Table V.

Season. 1913—	Number of days' samples.	Average B. coli per 100 c. c. of— Raw water.	Filtered water.
January	31	3,462	1.6
February	28	272	1.0
March	31	782	0
April	30.	931	2.3
May	31	196	1.9
June	30	283	0
July	31	378	5.1
August	31	277	.6
September	30	294	0.3
October	31	131	1.2
November	30	178	1.3
December	31	33	.3
January to December	365	606	1.3

Washington, D.C.—Washington, D.C., has a slow sand filtration plant. There is large reservoir capacity and some alum is used in times of high turbidity. No hypochlorite or chlorine is used at any time. The general average for the Washington plant for 348 samples shows

Table VI.

Season.	Number of days' samples.	Average B. coli per 100 c. c. of— Raw water.	Filtered water.
1913—			
January	25	4,582	7.4
February	23	502	1.0
March	25	2,871	.5
April	26	20,910	4.1
May	26	661	0
June	25	910	0
July	26	5	0
August	24	88	0
September	25	412	.5
October	27	622	4.7
November	23	1,167	.5
December	25	538	.5
1914—			
January	25	640	0
February	23	211	.5
January, 1913, to February, 1914	348	2,501	1.4

1.4 B. coli per 100 c. c., which must be classed as a very good effluent. A close study of the results for individual months shows that there is great fluctuation in the character of the raw water. There was a very bad raw water in January, 1913, and April, 1913, and the results show that this unreasonable burden was probably too much for the purifying capacity of the plant. Table VI. shows the results of filtration in Washington, D.C., by months:

Birmingham, Ala.—The water supply for Birmingham is derived from two separate sources, as follows:

(*a*) Five Mile Creek, which is a stream to the north of the city, having a minimum flow of four and one-half million gallons, with a watershed area of 16.1 square miles and a population density of 31.9 per square mile. Five million gallons daily is supplied from this stream except during the dryest seasons. The waters of Five Mile Creek are diverted at a point 6 miles from the city and brought by gravity through a closed conduit to the North Birmingham purification plant, which consists of sedimentation basins and rapid sand filters of 5,000,000 gallons nominal capacity and sterilization by hypochlorite. The analysis marked "North Birmingham" show the raw and the treated water of this supply during the year 1913.

(*b*) Cahaba River: The watersheds of Cahaba River lie to the east of Birmingham. The west prong or Big Cahaba furnishes the supply, except when its minimum flow is less than the daily pumpage, in which case the East Cahaba is drawn upon by means of a small diversion dam below the junction of the two rivers. To supplement the dry-weather flow, a dam has been built on the east fork, or Little Cahaba, and a large impounding reservoir of 1,250,000 gallons created, known as Lake Purdy. The total watershed area is 205 square miles. The area above Lake Purdy is 49.7 square miles. The density of population on the entire shed is estimated at about 20 per square mile.

The pumping station on the Big Cahaba, 2 miles above the diversion dam at the junction of the two forks, forces the water to a purification plant on Shades Mountain. The purification plant consists of two large sedimentation reservoirs, holding 118,000,000 and 28,000,000 gallons from which the water flows by gravity through a rapid sand filtration plant, having a present nominal capacity of 19,000,000 gallons daily, with eight additional million under construction. The filters discharge into a clear-water basin of 3,000,000 gallons capacity, from which the water flows by gravity to the city, a distance of four miles.

Cahaba Plant.
(No chlorination.)

Season. 1913—	Number of days' samples.	Average B. coli per 100 c. c. of— Raw water.	Filtered water.
Jan. 1 to Feb. 28	25	305	0.28
March 1 to April 10	35	305	.56
April 11 to May 21	35	87	.00
May 22 to July 21	35	204	2.28
July 23 to Oct. 20	35	112	1.4
Oct. 22 to Nov. 28	16	23	0.0
Dec. 1 to Dec. 30	14	323	4.2
Jan. 1 to Dec. 31	205	196	1.0

North Birmingham Plant.
(With chlorination.)

1913—			
Jan. 1 to Feb. 6	31	700	0.3
June 9 to July 25	33	800	.6
July 28 to Sept. 12	35	1,337	.3
Sept. 15 to Nov. 3	34	288	0.0
Nov. 4 to Dec. 31	41	240	.0
Jan. 1 to Dec. 31	174	400	.2

The two Birmingham plants furnish very interesting data also on the value of hypochlorite as an aid in handling a bad raw water. The Cahaba plant uses no hypochlorite. In December, 1913, raw water, with an average of 323 B. coli per 100 cubic centimeters, seemed to overtax the purifying capacity of the plant. A load of 204 B. coli per 100 cubic centimeters in June and July seemed to be about the limit that the plant could care for, although in the period from January 1 to April 10 an average of 305 in the raw water was reduced to less than 1 B. coli per 100 cubic centimeters in the effluent. The North Birmingham plant has a worse raw water to deal with. This plant uses hypochlorite as an adjuvant. The average for raw water of 700, 800, and 1,337 B. coli per 100 cubic centimeters was reduced to less than 1 B. coli per 100 cubic centimeters in the effluent. From September to December, with a fair raw water averaging 240 and 288 B. coli per 100 cubic centimeters, a perfect result was obtained with entire absence of B. coli in the 71 samples.

Following a sanitary survey of the cities and towns in the basin of the Great Lakes, the writer recommended, among other things necessary, that a standard for filtered or treated water be established which should be a minimum requirement for the prevention of the spread of water-borne disease in interstate traffic. The Surgeon General of the Public Health Service appointed a commission in January, 1913, to fix such a standard. The report of this commission will be published soon. The majority of the members favored a standard of four negatives out of five 10-cubic-centimeter tests for B. coli. The writer expressed this standard in a different way, recommending a standard of not more than 2 B. coli per 100 cubic centimeters of water, taking the average of many samples by Phelps' method.

Allowing a sufficient margin of safety, filter plants with a decent raw water should produce effluents of less than 2 B. coli per 100 cubic centimeters, and it is the opinion of the writer that a modern water-purification plant which delivers an effluent which has more than 2 B. coli per 100 cubic centimeters is either inefficiently operated or is dealing with a raw water which imposes an unreasonable burden upon the plant. Accepting tentatively the standard of less than 2 B. coli per 100 cubic centimeters as a good drinking water, although not perhaps an ideal drinking water or a safe drinking water at all times, the results indicate that this standard is attained by both "rapid" sand and slow sand plants, even with a very bad raw water. Cincinnati and Washington, D.C., are good examples of each type. Close examination of the daily records at Washington and Cincinnati show that while this excellent average is attained for the year, there are periods when the capacity for purification seems to be overtaxed by the very bad raw water. At Cincinnati, the use of hypochlorite seems to compensate for the deficiency in purification by the standard process, but in Washington the excellent general average of 1.4 is only attained by the almost perfect purification effected during periods when the raw water is fairly good.

There is a strong tendency in America to accept any raw water, however bad, as a source for a municipal filtration plant. This often imposes an unreasonable burden and responsibility upon the water-purification plant. Now, filter plants are not infallible. They are mechanisms which must be properly constructed and efficiently operated under careful bacteriologic control in order to secure a safe effluent. They are operated by human agency and subject to the results of human error. It is true that properly constructed and efficiently operated filter plants can produce safe water from a very bad raw water, especially by the use of hypochlorite or liquid chlorine as an adjuvant. The responsibility of effecting such purification every hour of every day in the year is unreasonable and unfair. Many plants are now struggling with a raw water of such a character that a safe effluent is only obtained at the price of eternal vigilance, perfect operation every day in the year, and the free use of auxiliary chemicals. The raw water demanding such extraordinary treatment is, like a sword of Damocles, constantly threatening disaster. There is no margin of safety under such conditions.

I believe that a sufficient margin of safety should be given to all filter plants by reducing the pollution of the raw water to a point where it would not impose an unreasonable burden or responsibility upon the plant. I believe that in reckoning the bacterial purifying capacities of filtration plants hypochlorite or liquid chlorine should not be considered, but that a raw water should be furnished of such a character that the plant could turn out constantly a safe effluent without the aid of chlorine. This would reserve the chlorination as an additional margin of safety for use in extraordinary fluctuations of the raw water or during accidents to the plant or interruptions in its ordinary efficiency.

GRANITE MINING IN UNITED STATES.

In a recently-issued United States Geological Survey bulletin on Graphite, it is stated that to-day there are more abandoned graphite mines and mills in the United States than the number in operation. The number of times that some of these properties have changed hands in the course of a few years evinces a record of misrepresentation and disappointment that can hardly be equalled in any other branch of mining, and many properties have been notoriously associated with stock manipulations of doubtful character. It should be clearly understood by anyone who contemplates the development of one of the flake graphite deposits that the technology of concentrating such materials is yet in its infancy; that there are no well established systems of treating the materials, such as exist, for example, for the treatment of gold or copper ores; and that the product obtained is variable in quality and in market value and subject to severe competition with foreign graphite. The largest part of the foreign graphite that comes into the country is brought in by firms, who either control or own foreign mines or have purchasing agents abroad. and are, therefore, in a position to take immediate advantage of any change in the markets at home or abroad. In general, the cost of producing flake graphite is so high and the price at which it is sold so low that even under the most economic conditions the margin of profit is small. Moreover, certain rocks that carry graphite contain other minerals in such intimate association with the graphite as to preclude any possibility of successful concentration—such, for example, are rocks in which graphite flakes are interleaved with mica—and a careful study of the material by an expert should precede any attempt at development.

One large power-station after the other is being built in Norway, where the water-power has given a tremendous impetus to the development of the country's industry. The Sandefaldene Company is about to exploit the different falls in the Sande water system, for which the different lakes, some of them lying at a considerable height, will be regulated so as to serve as reservoirs. There will be constructed three power stations in the valley, and a larger one at the sea, the aggregate power being about 80,000 horse-power, divided between the four stations with respectively 42,000, 10,000, 8,000 and 20,000 horse-power. The whole of the power will be transmitted to the sea, where it will be used by an American concern—the Union Carbide Company—which has contracted for 40,000 horse-power, with the option of another 40,000 horse-power. The Sandefaldene Company has secured large areas at the sea for the new town which will no doubt spring up there within the first few years.

DETERMINATION OF THE LEGAL CHARACTER OF QUEBEC RIVERS AND THEIR CLASSIFICATION.

The Quebec Streams Commission was appointed in 1911. One of its duties was to consider whether it was expedient to have the rivers of the Province classified as navigable and floatable rivers, or otherwise, according to uniform rules, and to submit such rules, if advisable. The work, during the past two years, has included an investigation of the nature and causes of existing difficulties, jurisprudence in connection with the legal character of rivers, foreign legislation, character and importance of the rivers, and practical conclusions to be deduced. In the second annual report of the Commission, recently published, these studies are shown to have been quite exhaustive. Classification of rivers was based on the area of the basins drained. Watercourses with drainage basins over 300 square miles in area were considered important, from the viewpoint of the utility of which each is susceptible. From this point of view of importance is deduced the legal character of the stream. The report lists 187 such rivers falling under this category, besides those in the territory of New Quebec. Thirteen of these rivers have drainage basins exceeding 11,000 sq. mi. each in area.

With respect to the investigation, the Commission expresses the belief that it is now necessary:—

1. To proceed to classify rivers according to uniform rules;

2. To change the formula, which serves to determine their legal character in the Province so as to remove the difficulties now encountered in connection with such determination;

3. To adopt a more convenient formula on a fixed, stable and certain basis susceptible of extended and decisive application;

4. To adopt as the principle in classification the importance of the river, stream or watercourse from the standpoint of the various uses of general interest for which it may serve;

5. To adopt a classification which shall be at once collective and individual or nominal without, however, being limitative in so far as the right of the Province to modify it is concerned;

6. To take as the standard for such determination the extent or area of the drainage basin whose waters are received by the river or watercourse;

7. To adopt for individual classification the list laid down by the Commission of the best rivers in the Province, the area of whose basin is known. This would mean recognizing the principle admitted in France that the administrative authority is alone competent to define the natural fact, the actual condition which constitutes sovereignty instead of leaving the duty of defining such legal character as at present;

8. To recognize that these rivers possess or are capable of assuming the importance deemed sufficient to create sovereignty, that is which justifies or compels its recognition.

In the report of the engineer, it is pointed out that in Quebec adequate information has not been previously collected concerning rainfall within the province, and that data covering a lengthy period of years possesses a great value in work of this nature. There are 45 rain-gauging stations in Quebec, 17 of which were established in 1913. He advocates extensive improvements in this respect. Similarly, water gauges for all the principal rivers are a need that is emphasized.

DESIGN AND CONSTRUCTION OF ELEVATED TANKS.*

By W. O. Teague, Boston, Mass.

The elevated or gravity tank for fire protection systems has been from the first an important limited secondary source of water supply, and its value has increased greatly with the increase in number and size of tanks installed generally throughout the country, especially in those cities and districts where the public water supply is of low pressure. The tanks are usually located above buildings in cities and on detached towers in the country.

The tanks were first made of wood, but there are now as many being made of steel. Wooden tanks have been built up to 10,000 gal. capacity, although they are rarely larger than 60,000 gal., for above this capacity the steel tank is cheaper and more practicable. The cost of a 60,000-gal. tank of wood or steel erected on a 75-ft. steel tower is about $3,000. Steel tanks are built in large sizes, one of the largest being of 1,200,000 gal. capacity; this one is 50 ft. in diameter and 90 ft. high, and is supported by a steel tower 130 ft. high.

Failures of tanks in service, involving loss of life and destruction of property, have shown the need of more care in the designing and construction of them. To insure the best results, the following features should have attention:

Wooden Tanks.—The tightness and durability in the wooden tank depends chiefly upon the quality of the lumber and the details of its construction. Selected tank stock only should be used consisting of white cedar, cypress, white pine, Douglas or Washington fir, or redwood, and the lumber should be free from sap, loose or unsound knots, worm-holes and shakes, and be thoroughly air-dried. Both the staves and bottom are usually made up of 2½-in. stock dressed both sides, for tanks up to 16 ft. in diameter and 16 ft. deep; for larger tanks 3-in. stock is used. Plank for this purpose should be full length without splices.

The strength of the wooden tank depends principally upon the size and spacing of the iron hoops. The importance of the matter of the hooping will be appreciated when it is realized that overstressing of even one hoop may result in bursting of the tank. The wooden tank being originally merely a development of the barrel where flat hoops were necessary to permit of tightening by driving them toward the enlarged middle, it was natural to use also flat hoops for the tank and the tank was also made tapered so that the hoops could be tightened by driving, although later they were tightened principally by hoop lugs. It was claimed that the tapered shape had also the advantage of preventing the hoops from dropping down over the tank, if it was allowed to remain empty and the staves to shrink from drying.

The tapered shape of tank is not important, however, since a tank which has been allowed to dry up has been seriously damaged thereby and cannot be made tight without extensive repairs, sometimes necessitating the rebuilding of it. In fact, most tanks are now made without taper and the hoops are found to remain where placed. The tapered tank costs somewhat more to build since the staves must be fitted more carefully and the design undoubtedly would have been entirely discarded long ago, except that some architects and purchasers believe a

*Abstract of paper presented at the Annual Meeting of The American Society of Mechanical Engineers, 1913.

tapered tank presents a more pleasing appearance. The amount of taper is so small, being usually 1 in. per ft., thus giving a batter of ½ in. per ft. to each side of tank, that its absence is hardly noticeable except on very high and small diameter tanks. The only objection to the tapered tank, however, is its extra cost.

In the early studies of this subject, many serious failures of tanks were traced to weakening of the flat hoops by their rusting at the back where they bore against the staves, due to moisture from rain being retained

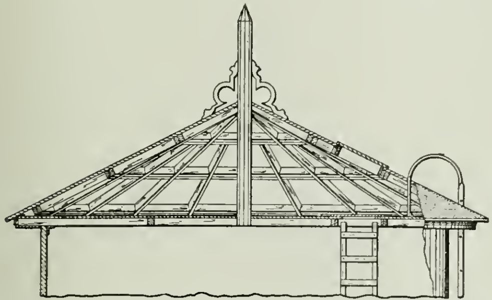


Fig. 1.—A Good Design of Double Roof for Elevated Tank.

between the surfaces of the hoop and staves. These failures were largely unpreventable, as it was difficult to properly inspect the condition of the hoops, and also impossible to paint them while the tank was in service. The use of hoops of round rod without welds has remedied this trouble as their surface is nearly all exposed for inspection and painting, and also they are not so subject to corrosion since the exposed surface of a round rod is much less than that of a flat bar or band of the same cross-sectional area.

Another point of weakness in the flat hoop is at its connection to the cast iron lugs which is usually made by riveting. The use of round rod hoops, however, permits of a satisfactory connection to the lugs, but at first many tank failures resulted from the use of light cast iron lugs. These are now made of malleable iron. The hoops are so placed on the tank that the lugs do not come in a vertical line.

Round rod hoops are so spaced that the stress will not exceed 12,500 lb. per sq. in. when computed from area at the root of the thread. The proper spacing can readily be found from the following formula:

$$\text{Spacing of hoops (in.)} = \frac{\text{Safe load for given hoops (lb.)}}{2.6 \times \text{diameter (ft.)} \times \text{depth (ft.)}}$$

The depth used is the distance from overflow to point where hoop is to be located. The top hoop is placed 2 in. from the top of the staves and the spacing between hoops should in no case exceed 21 in. An extra hoop or two is placed at the croze to take the additional strain due to the swelling of the bottom planks.

The tank roof, since it in no way serves to retain the water, has usually been nothing more than a makeshift cover. In the early days a single flat roof was used on outdoor tanks, but this held the snow and ice and required strong joist supports to keep it tightly in place. The snow also interfered seriously with the opening of the hatch to give access to the interior of the tank. A conical roof was then built over the flat one which remedied these difficulties. It also greatly increases the efficiency of the roof in preventing radiation of heat from the tank water in winter as it provides a dead air space between it and the flat roof in addition to the one between the latter and the water, thus reducing the cost of heating in freezing weather. The conical roof also gives a better appearance to the tank top. A well built roof is shown in Fig. 1. It should be tightly fitted around the tank top to maintain the dead air spaces.

Much trouble has resulted from leakage in the wooden tank, because it has not been firmly supported. The wooden tank is locally weak, not being of unit construction, and the lack of firm support has permitted working of the joints. It is supported only from the bottom, none of the weight being carried by the staves. Wooden beams were first used as supporting members, and these were placed on the roof of a building or tower as a grillage, and the tank bottom set on them. In time the wood rotted because of moisture from the tank bottom, permitting the tank to settle and causing leakage; there was also danger of collapse of tank because of this weakening of the joists. The use of steel I-beams as grillage members, as shown in Fig. 2, avoids these difficulties. The beams should not be spaced over 18 in. clear between edges of flanges, and the tank bottom is placed directly on the steel.

Steel Tanks.—The simplest form of steel tank is the flat bottom one and tanks of this type give satisfactory service, provided the bottom is supported by a steel grillage as in the case of the wooden tank. One possible source of trouble is from corrosion of the bottom, and to prevent this in so far as possible the bottom plates are made somewhat thicker than is necessary for strength alone, and the grillage I-beams are of a height and spacing to permit of inspection and painting of the bottom.

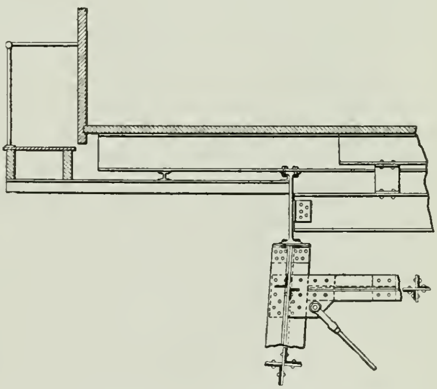


Fig. 2.—Detail View of Arrangement of Steel I-beam Grillage for Support of Tank.

When the tank is to be placed on a concrete tower, it may rest directly on a reinforced concrete slab with the bottom thoroughly grouted in place with neat cement.

The preferred form of a tank to be placed on a steel tower is that having a hemispherical or elliptical bottom. The construction in this form is cheaper than for the flat bottomed tank as the bottom is self-supporting and a steel grillage is unnecessary. The entire bottom is also accessible for inspection and painting, and corrosion is reduced to a minimum since the plates are exposed to the air.

Plates for use in steel tanks are made somewhat thicker than is necessary for strength in order to make

them durable against corrosion. The minimum thickness is 1/4 in., except that 1/8-in. plates are used for roofs. The plates composing the lowest cylindrical ring are 5/16 in. thick for 60,000-gal. tanks and larger, and the bottom plates 5/16 in. thick for tanks 75,000 gal. and larger.

One of the weaknesses of steel tank construction in the past has been poorly designed connections of the tank shell to the posts of the supporting tower. When the posts have a batter, as is usually the case, the inward thrust due to the horizontal component of the weight is provided for by a circular girder consisting of 1/4-in. plate 24 in. wide, attached to the lowest cylindrical ring by an angle and stiffened by angles or a channel at the outside edge, as shown in Fig. 3. The posts also connect to the tank shell at this point and the design is such that the load will be transferred from the shell to the centre line of the posts so as to avoid eccentric loading. A number of tanks built without circular girders have failed by the posts crushing in the tank plates. Others with the girder, but having eccentrically loaded connections to the posts have failed by bending of the upper posts.

As the hydrostatic pressure on the tanks is comparatively small, it is not necessary to provide standard riveting for the thickness of plates used. The joints of the plates should be riveted so that the unit stresses on the net section of the plates and rivets will not exceed 7,500 lb. for shearing and 20,000 lb. for bearing. The horizontal joints are single lap riveted, except between the lowest cylindrical ring and the bottom, which are double lap riveted. The vertical joints also are single lap riveted except those in the lowest cylindrical ring, which are double lap riveted. The rivets are entered from the outside and driven from the inside and inside seams caulked. One of the strong features of the steel tank is that when

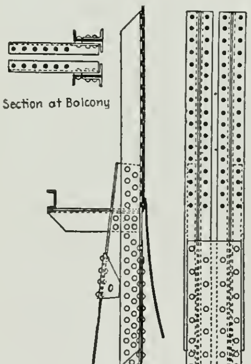


Fig. 3.—Detail of Attachment of Tank Shell to Tower Post and Circular Girder Construction.

once made tight, it gives practically no trouble from leakage.

Towers for Elevated Tanks.—Towers to support wooden tanks were originally built of wood, but with the increases in size of plant buildings and extensions of them, considerably larger tanks and higher towers were required, and the builders, realizing the inadequacy of wooden construction under these conditions, began to make towers of steel. The managements not being experienced in structural steel designing, naturally selected the simplest design possible for the towers. The posts and girts consisted usually of two angle irons, placed apex to apex and strapped together at intervals of several feet by tie-plates shop-riveted to the angles. The column sections were spliced by angles which were shop-riveted at one end to the post; the other end was field-bolted in erecting the tower, as this was the simplest form of connection and the easiest one to make. Furthermore, it had the advantage that the bolting could be done by the regular erecters which made it unnecessary to have first-

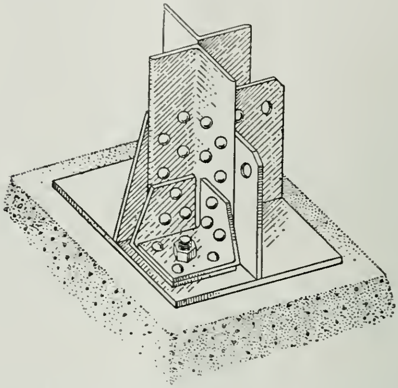


Fig. 4.—Typical Construction of Footing for Angle Iron Column.

class mechanics in the erecting gangs and to carry special tools. This, however, was not good construction and the manufacturers are now field-riveting these connections.

The struts were at first connected directly to the posts by bolts. This construction is objectionable because the bolts are apt to work loose and it does not brace the parts. The construction now used is that of gusset plates riveted to the posts and girts. The wind rods were also connected directly to the posts at the girts. The bolt holes, as originally inserted through the post angles, weakened the posts since they reduced the net section. The rods are now connected to the gusset plates. The arrangement of these parts is shown in Fig. 2. The diameter of bolt and thickness of plate are proportioned to provide proper bearing strength. The posts and girts of steel towers erected to support steel tanks, and to some extent wood tanks, are now largely made of channels latticed on both sides or having a plate on one side. Other shapes such as the Bethlehem H-beam and two channels with an I-beam between to form an H-section are also used to some extent.

Competition in the manufacture of these structures has resulted in the use of too high unit stresses and as a result the posts, figured on a conservative basis as represented in case of their structural work such as bridges, had a factor of safety of less than four and sometimes as low as two and one-half and failure has resulted. To obtain safe towers it became necessary, therefore, to set maximum allowable stresses. The loading of the structure consists of the weight of the structural and ornamental steel work, platforms, roof, piping, etc. The live load consists of the weight of the total volume of water; the movable load on the platform is assumed to be 30 lb. per sq. ft. and the wind load. The wind pressure is assumed at 30 lb. per sq. ft. on flat vertical surface and the

wind load on the tank is taken as this pressure times 6/10 the projected area of tank and roof, and in the case of steel tanks, the curved bottom. The total wind load on the posts, struts, wind rods, ladders and riser boxing is assumed at 200 lb. per linear foot of height of tower.

All parts of the structure are proportioned so that the sum of the dead and live loads shall not cause the stresses to exceed those allowable. The principal stresses in such

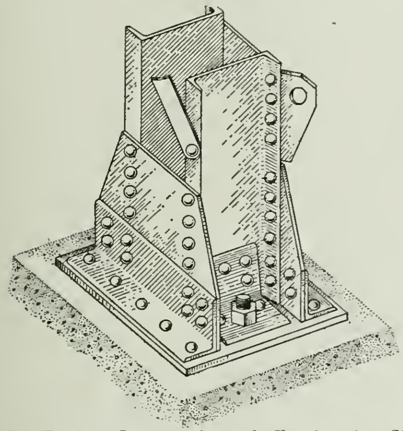


Fig. 5.—Typical Construction of Footing for Channel Column.

a tower structure are axial compression on gross section of columns and struts, axial tension on net section of wind rods, bending on extreme fibres or net section of rolled shapes, built sections and struts, and shearing of rivets. The axial compression on gross section of columns and struts is determined from the following expression: $17,100 - 57\frac{L}{R}$, where L is the unsupported length of the members from centre to centre of connections in inches, and R the least radius of gyration in inches; the ratio $\frac{L}{R}$ should not exceed 125 for columns and 150 for struts and minor members and the maximum compression allowable as thus determined is 12,000 lb. per sq. in. The axial tension on net section of wind rods must not exceed 12,500 lb. per sq. in.; the bending on extreme fibres or net section of rolled shapes, built sections and struts 16,000 lb. per sq. in., and the shearing for shop-driven rivets, 10,000 lb. per sq. in. and field-driven rivets 7,500 lb. per sq. in.

The lower ends of the posts have not been as carefully designed as their importance requires. Frequently, in angle iron towers particularly, no special attempt has been made to properly distribute the load to the base plate attached to the post footing. Cast iron plates were first used and the concentrated loading caused these to crack, resulting in collapse or in throwing the structure dangerously out of plumb with possibility of failure of the foundation under this post. The present use of steel plates has improved conditions, but the design must be such as to distribute the load to them as shown in Figs. 4 and 5, which are designs that are being used quite generally.

In anchoring the columns to the foundations, the diameter of the bolt at root of thread should be such as to withstand the maximum uplift due to the wind with tank empty, and to resist the shearing force at base plate. The bolts should be made from round wrought iron or mild steel rods without upsets.

Foundations and Supports.—The foundation piers to support steel towers are usually made of concrete, consisting of one part portland cement, three parts clean sand and five parts broken stone. They are usually pyramidical in shape and proportioned to suit soil conditions. The allowable bearing pressures on soil will range from 1 to 5 tons per sq. ft., depending on the quality of the soil. Where the soil is moist or rather loose, a girt should be provided at the base of the tower to prevent spreading of the posts. The allowable bearing pressures for footings should not exceed 400 lb. per sq. in. for Portland cement concrete and 200 lb. per sq. in. for ordinary brick work with Portland cement mortar, except when tank is to be rested on building walls, when the bearing plate should be figured on the basis of 125 lb. per sq. in.

The weight of the foundation pier when buried at least two-thirds of its height should be equivalent to the calculated net uplift due to wind pressure with the tank empty, that will be transmitted to it; otherwise it should be one and one-half times that amount.

Where the tank structure is above a building, and the building walls are depended upon to act as supports, great care should be taken to determine that the construction is safe against collapse. In many cases, tanks are supported by building walls not originally built to carry them, but where a sprinkler system was later installed it was considered more convenient and cheaper to use the walls than to erect a detached tower for the tank. This has frequently been done without making a thorough inspection first of the condition of the walls, and, largely through ignorance, the necessary care was not taken to distribute the load. Many failures have consequently resulted and there are no doubt numerous cases of this kind where the tanks are apt to fall at any time.

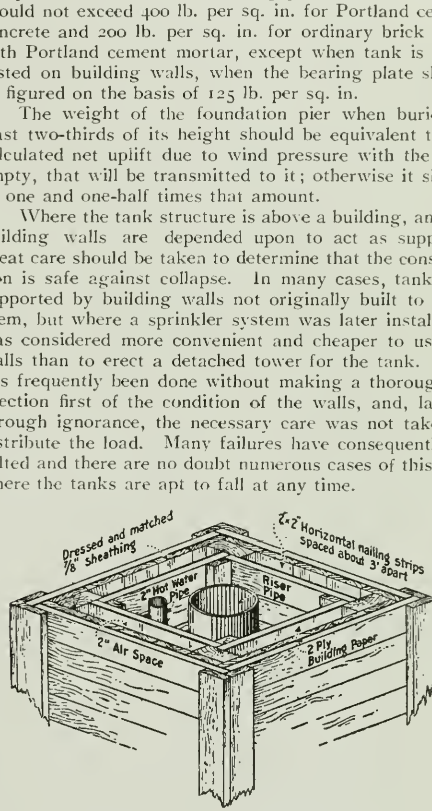


Fig. 6.—Design of Efficient Frost-proof Square Boxing for Enclosure of Riser Pipe to Tank Connection.

Inspection should be made of the quality and condition of the brick and mortar or other material used in the construction. The wall foundations should be examined as to construction and bearing on soil or rock. The condition of the bond between abutting walls should be noted and a general inspection made for sizable cracks in the walls. The thickness of walls and size and spacing of window and door openings should be measured and calculations then made to determine if the load of tank, water and trestle can be safely distributed over the walls. All unnecessary openings should be bricked or otherwise solidly filled in, and it may be necessary to sacrifice some openings to obtain the required strength. When the walls

cannot be altered to support the load, the additional support required can be obtained by carrying steel beams down inside the walls to a solid foundation, provided these do not interfere with occupation of or possesses carried on in the building. Otherwise it will be necessary to provide a separate steel tower.

The proper strength of foundations is especially important because of the greater probability of loss of life from the falling of a tank from above a building as compared with the falling of a tank on a detached tower. The monetary loss is liable, of course, to be also much greater, as the water will undoubtedly wreck the building and cause heavy water damage. The building departments of cities endeavor to obtain proper construction, but unfortunately they do not always succeed. The possibility of trouble is increased because of the divided responsibility of the tank builder and the architect. The former seldom concerns himself as to the strength of the supporting walls, assuming that the latter has given the matter proper attention, so he goes ahead and erects the tank according to contract.

General Features.—Tank fittings should receive careful attention to insure the reliability of the equipment. The discharge or riser pipe is more serviceable if made up of cast or wrought-iron pipe, flanged or coupled, than one made up of bell and spigot pipe, since the latter is apt to leak at the leaded connections, necessitating removal of the frost-proof boxing to permit of repairs. A tank and tower is constantly swaying from side to side and this tends to loosen up leaded joints. Furthermore, the increased rigidity of the flanged and coupled pipe permits the use of a minimum number of tie rods. There are usually four rods connected, one to each post, at girt connections.

The connection of the discharge or riser pipe to wooden tanks has usually been made by extending the pipe through ordinary cast-iron slip flanges bolted to the tank bottom on each side of the opening. The hole in the planks was cut larger than the size of the pipe to form a packing space which was filled when parts were first assembled. A better construction was used for steel tanks having a stuffing box and gland. Both types of joints were found to be unserviceable, however, the former because the joint could not be tightened when leakage occurred, and the latter principally because the iron to iron parts rusted together, which resulted in the breaking of some pipe fittings and the emptying of the tank. Properly designed expansion joints forming tank connections for wooden and steel tanks have a bronze gland and ample clearance between the iron parts to prevent binding by corrosion. The packing space is large and the joint is extended within the tank bottom to form a settling basin, to prevent sediment getting into the yard pipe and clogging the sprinklers at time of fire.

A tightly constructed frost boxing should be placed around the discharge or riser pipe, and arrangements made for keeping the water heated by a hot water heater or a steam coil in the bottom of the tank. Designs of three-ply, two air-space boxings are shown in Fig. 6.

A tank level indicator or telltale is necessary to give a positive indication that the tank is full at all times. After many serious fires it has been learned that the tank had been partially or wholly empty at the start of the fire, and the lack of water had handicapped the fire protection devices. Tanks may be left empty due to neglect, but usually so because of false indication of the telltale. The most used type of device for this purpose is the float in the tank water, operating a target sliding on a scale fixed to the outside of tank. Obviously, these are subject to sticking due to their mechanical construction and exposure to snow and ice in freezing weather. The ordinary pressure gauge has been largely used but cannot be positively depended on, since it is seldom, if ever, tested and the parts stick, causing false readings. There are several types of electrical telltales operated by a float, but these are complicated and easily gotten out of adjustment. Attention is also necessary to maintain the electrical current.

The most reliable telltale is undoubtedly the mercury gauge. It should be placed indoors where it will be observed and cared for. The mercury pot is then piped to the riser pipe on the tank side of the check valve, and the gauge board adjusted after filling the mercury pot. The gauge is readily tested by opening the pet cock on the water pipe. If water continues to flow under constant pressure, the apparatus is in operative condition; otherwise, the pipe is clogged or there is a valve closed.

The painting of steel tanks and towers and of the iron hoops of wooden tanks is very important to prevent corrosion. Steel plates and shapes should be given the usual priming coat at the shop. The surface of the metal should be thoroughly cleaned of mill scale, rust and grease and be perfectly dry before applying the paint. A good paint for the first coat is made by mixing 20 lb. of red lead and 10 lb. of zinc oxide with 3 qt. of boiled linseed oil, the red lead and zinc oxide being ground in. This amount of paint will cover about 50 sq. yd. of surface. A second coat should be applied after structure has been erected. For this a more durable oil or asphaltum paint should be used.

The inside of a steel tank should be repainted, usually every two years, or oftener, if the paint shows signs of peeling or wear. The outside of the tank and the tower should be repainted at about five-year intervals. The surface should be carefully cleaned either by sand blast or by steel brushes or scrapers.

The iron hoops of wooden tanks should receive a priming coat as for structural steel and a second coat after assembly. They should be repainted when necessary. The advisability of painting wooden tanks exposed to the weather is an open question, although a large percentage of the tanks are painted. There is no doubt but that paint protects wood under ordinary conditions, but the objection raised to its use on tanks is on the ground that the tank water percolates through the staves and is prevented from evaporating as it is held under the paint and this is likely to set up dry rot in the wood. It is well-known, however, that dry rot does not occur when wood is completely immersed but rather when it is in a moist condition in the presence of some heat. This objection is not considered well-founded and as a rule the tanks are undoubtedly preserved by painting.

The life of properly constructed equipments depends largely upon the care and attention given to them by property owners. The tanks should be used only for fire protection. The practice of using a foot or so of water from the top of the tank for mill purposes is objectionable as the tank collects a larger amount of sediment from the water which is constantly being supplied than it does when used for fire service only. This sediment is likely to settle in the sprinkler pipes and either clog them completely, or, if the sprinklers are open, seriously interfere with their discharge. If water is drawn from the bottom for mill purposes the tank may be empty when needed for fire service. Furthermore, the fluctuation in water level is apt to result in shrinkage of the upper ends of the staves of wooden tanks, causing leakage and hastening corrosion in the steel tank by the repeated wetting and exposure of the sides to the air.

SLAG AS A ROAD-SURFACING METAL

Slag is a product obtained during the reduction of iron ores, and has been used to a small extent as a surfacing material for highways and to a large extent as ballast for railroads. The slag that is used in this capacity is generally silicate slag, resulting from the smelting of iron ores in blast furnaces, and is produced by a combination of a flux and the earthy matter of the iron ore. As is well known by all persons familiar with the smelting of iron ore, blast furnaces are charged with alternate layers of fuel, ore and a flux, usually limestone, fresh material being added from the top as the charge works down. The blast is introduced through tuyeres near the bottom of the furnace, and except during the time of charging and tapping these furnaces, it is continual. The iron, reduced from its ore by carbonic oxide or other reducing agents, descends toward the furnace together with the slag which results from the union of the earthy matters or the gangue of the ore and the flux; the slag, being of less specific gravity than the molten pig iron, flows upon the surface of it.

The quality of the slag necessarily varies, the variations being due to the complex action of the blast furnace; to differences in quality of the ore, fuel and flux at various intervals; to lack of uniformity in charging and to differences of temperature, atmosphere, etc.

As the slag reaches a certain point in the furnace, it is continually running off, and amounts to approximately one ton for each ton of iron that is made.

From the above, it will be readily seen that the production of blast furnace slag and the reduction of iron ore into pig iron results in an immense tonnage production of this slag material each year.

The physical differences of slags, even upon casual inspection, are very obvious. They differ in hardness, density, porosity and color. Slags which contain approximately 40 per cent. silicate, 40 per cent. lime and 20 per cent. alumina are considered to be about the best for road-surfacing purposes. When these percentages vary greatly, slags are apt to be weak and to disintegrate when exposed to air or water.

There are two methods of disposition of slag as it is drawn from the blast furnace. The one usually used is that in which the slag is drawn off in the molten condition into large automatic dump ladles, holding approximately 150 tons each. These ladles are then hauled along a track to the edge of a bluff, where they are dumped, allowing the slag to run out in thin layers to cool. The surface of the slag bank soon solidifies, although the bank formed remains warm for a considerable length of time, and it is generally believed that slag banks should be allowed to harden for at least two years before the slag can be used to advantage for highway purposes.

The other method of disposing of this slag when it is being drawn from the blast furnace is to run it into a large vat of water, where, due to the action of the liquid, is formed what is known as granulated slag, a fine, crispy, glassy product, which, has been used with some success as a substitute for sand in concrete mixtures, although in general this granulated slag is disposed of as waste material or used to form embankments in place of earth.

Slag as a road surface has been used occasionally during recent years, in localities where there is a scarcity of suitable sand and gravel for road metal. The New York State Highway Commission considered the feasibility of its use last winter, in some of the counties in the south-western part of the State. Samples were tested at Albany to ascertain whether the characteristics of this material were such as to justify its use. The results were such that the Commission authorized the specifying of its use in various types of construction. An article appearing recently in the official organ of the Commission, and written by F. S. Strong, one of its division engineers, is based upon this departure. From it this information has been obtained.

The types in which the use of slag is allowed include plain concrete pavements, concrete pavements with bituminous surfacing, Hassam concrete pavements, water-bound slag macadam with and without glutrin, some with limestone screenings and some with slag screenings, and bituminous-bound slag macadam highways. Much of this work is now under contract, and a considerable portion of it will be completed this year. The material is also being used to some little extent as a surfacing material in the repairing of old macadam pavements.

It is believed that the careful and continuous future inspection of the highways built of slag will produce valuable information and statistics of its merits as a road metal.

A big bulk of the slag available in the section of the State referred to consists of blast furnace slag. However, in the further reduction of pig iron in the production of steel, various processes are used, as, for instance, in the open-hearth furnace, where the crude metal is further purified, here again a flux is used which rises to the surface of the molten mass as slag. Slag formed in this operation has been used but very little on account of the small quantities available for highway purposes, although it possesses many desirable qualities, such as hardness, toughness and excellent cementing qualities.

The use of this latter form of slag will be taken up below in the discussion of streets constructed in the city of Cortland during the last ten years with excellent results.

In the vicinity of Youngstown, Ohio, in 1909, the office of public roads in co-operation with the Carnegie Steel Company conducted a series of experiments to determine the best method of utilizing this slag for road construction. In the experiments at this place, the blast furnace slag was taken from a bank that had aged about two years, the material of which came from six blast furnaces of the same type. A steam shovel was used to load the slag from the bank into large gondola cars. These cars were drawn to a gravity screen, where the slag was dumped into a chute and passed over the screen to separate into proper sizes. After passing over this screen, it was taken by rail to a site about one and one-half miles from the road upon which it was to be used, unloaded and hauled to the road.

These experiments as shown by the bulletins issued by the office of public roads, proved very interesting, and demonstrate that there is a field for blast furnace slag in the construction of highways, and the results were so favorable that the various counties and the State Highway Department of Ohio have adopted standard specifications for the use of this material. Various reports of inspections made of these roads show that they have stood up well, and, owing to the cheapness in the first cost of this material and the lightness in weight, the investment in a slag furnace macadam pavement from an economic standpoint would seem to compare favorably with that of a stone macadam pavement.

Since the completion of these experiments, which were conducted with slag which was not run through a crusher but was taken directly from bank and screened, slag pavements have been constructed from commercial blast furnace slag, the slag being carefully sorted to obtain the best materials and run through a regular stone crusher in order to obtain the proper sizes for use in the various courses of macadam, resulting in superior types

of construction and more uniform and lasting types of pavements.

In the vicinity of Buffalo, where there are many large blast furnaces, this slag has been used to some little extent for highway work, although no intelligent effort was made to obtain a high-class construction, due to the lack of available money for said purposes in the localities where the work was done. Yet this material is found to consolidate under traffic without rolling, harden and smooth out, making an excellent country road. Where incisions were made in some of these roads for various purposes, it was found almost as difficult to cut through this material as to cut through a concrete foundation for brick pavement.

At the beginning of 1913 a plant was established in connection with the Buffalo Union Iron Furnace to take over the slag product of these blast furnaces and produce therefrom a commercial product to be known as crushed screened slag for railroad ballasting and highway surfacing purposes. During the season of 1913 a considerable amount of this material was used on town highways, and reports received from various town and county superintendents in districts where this material was used, stated that satisfactory results were obtained, although thus far it is too early to reach any conclusion as to the definite wearing qualities of this material.

In reference to the use of slag product in the open-hearth process in the manufacture of steel, perhaps some of the most successful work of this kind in the construction of streets or highways is that which has been done in the city of Cortland. In this city the first slag street was constructed ten years ago as a waterbound macadam highway, and, according to the city authorities, has given excellent results ever since. They also have other waterbound slag roads which have been built eight years with practically no repairs of any nature. During the last four or five years the city authorities have used a bituminous material asphaltic binder in the construction of the slag streets, using the penetration method with excellent results. The slag after being cooled is crushed in an ordinary stone-crusher, the larger pieces being used in the bottom course, which is bound with loam. For the body of the top course, a slag varying in sizes from 3/4 in. up to 2 in. is used. This top course has a finished depth of 3 in., and is bound with a gallon to a gallon and a half of asphaltic binder to the square yard; is then filled with slag screenings and rolled. These streets have also the appearance of sheet asphalt pavements and are standing up well under fairly heavy traffic.

The report which was distributed by the international joint commission appointed by the governments of the United States and Canada to investigate the pollution of the international waterways along the boundaries, dealt exhaustively with the sources of water supply and the contamination of these supplies by sewage. It pointed out that steamboats crossing the lakes take drinking water from contaminated areas 16 miles from land, that the water supply at Detroit and Windsor, and the western frontier of Ontario is not only exceedingly bad, but dangerous, and that some deaths are undoubtedly due to the infected water service for drinking purposes on the ferries plying between Windsor and Detroit.

The water power branch of the interior department of the Canadian government is arranging to put in the Canadian building at the Panama Exhibition at San Francisco an exhibit, showing the vast power resources of the Dominion. The exhibit is to include a series of models of typical power plants from the Atlantic to the Pacific. They will be arranged in a semi-circle in front of an enormous landscape painting of the Dominion, which is now being executed by Gibson Catlett, Toronto. The painting will be 75 feet long by 9 feet high.

DETERMINATION OF CARBON IN IRON AND STEEL.

THE following direct method for the determination of carbon content of iron and steel is outlined in an article, by W. D. Brown, appearing in a recent issue of Metallurgical and Chemical Engineering: The essentials for complete combustion are an initial temperature of the furnace of about 1800° F., the burning of the metal in nearly pure oxygen, and an unlimited supply of the latter during combustion. If the metal is pushed into the furnace and a slow stream of oxygen started, combustion will begin before all the air has been displaced and will be in a mixture of air and oxygen; possibly the combustion of the iron will be complete before the oxygen has completely displaced the air and the only work remaining for the oxygen is to displace the carbon dioxide in the tube. When the combustion begins, oxygen should be supplied as fast as the iron will combine with it, that the temperature may be raised to the highest point; about 3000° F. will be momentarily obtained and all the carbon will be oxidized. These requirements of starting combustion in oxygen and an unlimited oxygen supply have been met in the method described below. In addition the supply of oxygen has been made automatic.

Apparatus.—The electric furnace contains a silica tube 7/8 in. in diameter and 24 in. long; in it ignited asbestos is loosely placed from the exit end to within 3 in. of the middle of the furnace; this acts very well as a catalizer, and is necessary when burning pig iron, at least. Oxygen is obtained in 100-ft. cylinders on which is a pressure reducer and regulator which supplies oxygen at a pressure from 1 to 3 lbs. as desired. The regulator is connected to brass piping containing four tees and globe valves for four electric furnaces (more could be added as desired), thereby one tank is used for the four furnaces. Oxygen enters the silica tube through one hole of a two-hole stopper. In the other hole is a 12-in. copper or glass tube, 1/4 in. outside diameter; on the end of the tube is a No. 00 single hole rubber stopper. Through this stopper and tube a plunger rod of No. 9 nichrome wire, 24 in. long, to which is riveted a sheet of nickel about 1/2 in. diameter, is inserted. This is used to push the boat into the hot part of the furnace after the oxygen has displaced the air and while the current is flowing, and can be made in any laboratory; the No. 00 stopper can very well be replaced by a small stuffing box, in which case the copper tubing is shorter. The oxygen being free from CO_2, no purification is necessary. Both ends of the silica tube are cooled by copper water jackets.

The exit end of the tube is connected by a rubber stopper to a glass stopcock, which is used to regulate the flow of gas. The stopcock is connected to a 5-in. drying tube filled loosely with phosphoric anhydride. It has been found that a zinc tube is not necessary, as the sulphur trioxide fumes are caught by the asbestos and phosphoric anhydride.

The drying tube is connected by a rubber tubing, on which is a pinchcock, to a Vanier potash bottle. This bottle contains a solution of potassium hydroxide (purified by lime) of 100 grams per 100 c.c. water. The inner tube is filled with phosphoric anhydride and a covering of glass wool placed thereon. Filled in this manner, the bottle will last for 100 determinations. The part which fails first is the phosphoric anhydride; a solution will form in the bottom of the drying chamber and will gradually grow until there is no more dry anhydride; this marks the life of the bottle.

On the construction of the Vanier bottle depends the success of the method; it must be so made that a speed of 400 c.c. per minute may be obtained without the gases passing out the lower end of the inner coil, which can be done if the lower end points or slants downward instead of being horizontal. The exit end of the coil should also be opposite the entrance to the drying chamber to prevent the splashing of the potassium hydroxide solution into the phosphoric anhydride.

The Method.—A blank is first run in the following manner: With all connections closed, the oxygen is turned on the line and the pressure varied until three lbs. are obtained. One or more bottles are then connected to the furnace or furnaces and the stopper inserted in the entrance of the silica tube, the stopcock in the bottle is then turned, the pinchcock opened, and the globe valves from the oxygen line opened full. Oxygen should then pass through the bottle at a rate of approximately 400 c.c. per minute, the pressure in the line dropping to 2 lbs. If the speed of the gas is not as great as this, the reducing valve should be so regulated as to increase the pressure. It may happen that one bottle will go faster than the other; in that case, the stopcock at the exit end of the furnace is to be partially closed so that all bottles have the same speed. When this condition has been obtained—the right pressure in the oxygen line and the stopcocks just right, no change is made until it is necessary to renew the bottle or tank. The stream of oxygen is continued for five minutes, the oxygen is then shut off at the globe valves on the oxygen line and, as soon as the flow of gas slackens in the bottle, the pinchcock on the rubber tubing leading to bottle is closed and, when the flow has completely stopped in the bottle, the stopcock is turned, the bottle is removed and weighed, preferably with a tare. This is repeated until the variations between weights is not more than three decimiligrams.

For the actual test, 1.36 grams of steel between 20 and 60 mesh or half gram iron, are weighed and transferred to a groove in alundum contained in a nickel boat. The bottle is connected to the furnace as above and the stopper turned, the pinchcock being closed. The boat is placed just within the silica tube, the two-hole stopper carrying the pusher is then inserted in the tube, the pinchcock opened and the oxygen turned on full at the globe valve. Oxygen then passes through at the rate of approximately 400 c.c. per minute; if the rate varies perceptibly from this it can be regulated by stopcocks at exit of silica tube. After gas has passed through for one minute, the boat containing the drillings is pushed into the centre of the furnace by shoving in the nichrome wire mentioned before, while the current of gas continues. In about one minute the drillings have become heated sufficient to burn freely and combustion then is very rapid, being complete in twenty seconds. During the combustion an unlimited supply of oxygen is at hand, as the globe valve is open full and the regulator is set for a definite pressure. The oxygen then passes through to sweep out the carbon dioxide formed, five minutes after the boat is pushed back being sufficient. The globe valve is then shut off and, when the flow of gas has slackened, the pinchcock is closed, followed by the closing of the stopcock as above described. The bottle is disconnected and weighed; increase in weight in grams, multiplied by 20 gives %C. when 1.36 grams steel has been used.

In routine work, one analyst weighs up four (or less) tests, places boats in furnaces and starts the gas flowing. During the one minute's wait, he examines stoppers, etc., for leaks, then pushes boats back and leaves furnaces for other work, returning in five minutes for the completion of the determination. This method can be used for the determination of carbon in steels ranging from 0.07 per cent. to 1 per cent. carbon, as well as on pig iron. Not only is the accuracy greater than with color determinations, but the time required for analysis by combustion is less than by color.

RAILWAY COMMISSIONERS' ORDER RESPECTING LOCOMOTIVE DEFECTS.

An important order has recently been issued by the Board of Railway Commissioners for Canada to railway companies under its jurisdiction. By it locomotive engines of railway companies subject to the jurisdiction of the Board will not be allowed to leave terminals, or to be used at terminals, in traffic service, on which any of the following defects exist, viz.:

1. **Steam Leaks.**—Steam leaks from any part of the locomotive which render it impossible for the engineer to see signals in sufficient time to enable him to bring his train to a stop within the required distance.

2. **Air Brakes.**—Air brakes on locomotives or tenders not in serviceable condition.

3. **Wheel Defects.**—Locomotives with steel or steel-tired leading engine truck wheels, leading or trailing driving wheels, or tender wheels with flanges worn 1/16 below M.C.B. wheel defect gauge for cars of less than 80,000 pounds capacity.

Locomotives with cast iron engine truck wheels and cast iron wheels under tender weighing over 130,000 pounds with flanges worn 1/16 below M.C.B. defect gauge for cars of 80,000 pounds capacity, or over.

Locomotives with cast iron wheels under tender weighing 130,000 pounds, or less, with flanges worn 1/16 below M.C.B. defect gauge for cars of less than 80,000 pounds capacity.

Locomotives with truck or tender wheels having shelled out or flat spots over 2½ in. long, or so numerous as to endanger the safety of the wheel.

Steel tires on locomotives worn hollow ⅜ in. in depth, or which are worn below safe limit of thickness. Railway companies to file with the Board their standard limit of thickness of tires on all classes of locomotives, for approval.

Flat or shelled out spots on locomotive driving wheels 3 inches long.

4. **Springs.**—Locomotives with defective springs on any part of locomotive or tender which are unable to carry their respective weights when locomotive is standing.

It is further ordered that the railway companies are required on or before the first day of January, 1915, to equip their locomotives with double windows in the front of the cabs during the winter season, November 1st to April 30th; the same to be made air-tight.

The order is the result of replies to a circular issued to the railway companies on February 24th last, and the reports of the operating officers of the Board, the railways consenting to the adoption of the regulations regarding locomotive defects as outlined above.

During the past 2 years, approximately $2,500,000 has been spent by the C.P.R. on the Dominion Atlantic Railway. The whole road is being modernized in its bridges and tracks. The biggest individual job was at the Bear River bridge, where $1,500,000 was spent. Other new bridges are those across the Avon, at Windsor, over the Gaspereau River, and at Weymouth. The C.P.R. will formally take over the road when it is brought up to the required standard.

MOOSE JAW 11th AVENUE SUBWAY.

THIS work comprises the construction of a subway 66 ft. wide under the Canadian Pacific Railway tracks and connecting the northern and southern portions of the city as divided by the Canadian Pacific Railway main line. The subway is situated two blocks east of Main Street at the north end at Manitoba Street and 11th Avenue, and passes diagonally under the tracks, connecting with 10th Avenue one block east of Main Street at its south end, which terminates at a concrete bridge over the Moose Jaw River.

The length of the subway is some 1,040 feet. A double line of street car tracks is laid from end to end with steel standards along the centre line. The vehicular roadway has a minimum clearance of 13 ft. 4 in. under the lowest members of the steel bridgework carrying the five C.P.R. tracks. The roadway, which is laid at a 4% grade, is 46 ft. between curbs, and paved with vitrified blocks laid on a concrete base varying from 5 in. to 18 in. in thickness according to the condition of the subsoil. On each side of the roadway 10-ft. concrete sidewalks with curb and gutter are provided for pedestrians.

Reinforced buttressed concrete retaining walls are built along each side, and heavy concrete abutment walls support the bridgework carrying the tracks. The elevation of the crown of the road at the lowest point, that is, under the centre of the tracks, is 1,751.14, being some two feet below the mean water level of the Moose Jaw River, which borders the south end of the subway. At the lowest point of the gutters catch basins are provided to take the storm water, which is thence conducted by 8-in. and 10-in. stoneware sewer pipes laid under the sidewalks, discharging into the low level of the river below the C.P.R. dam some 1,500 feet distant. The sidewalks in the lower portion of the subway have been constructed 3 feet above the roadway so that their lowest level is well above the high-water level of the river, and consequently immune from any possibility of being submerged during any flood.

Iron railings are provided for the protection of the public along the curbs of the raised sidewalks, and along the back edge of the sidewalks at the south end, which is bounded by the river on each side, or more correctly, by Moose Jaw River on the east and Thunder Creek on the west side, which join at the before-mentioned concrete bridge at south end of the subway.

Owing to the close proximity of the river, it was necessary to support the bridge abutments and a considerable portion of the retaining walls on closely piled foundations. These piles varied in length from 12 ft. to 18 ft., being driven to absolute refusal in practically every case. Also, to avoid the ill effect of a saturated sub-base by percolation from the river, Neponset waterproofing was laid on a concrete bed below the main concrete road-base throughout that portion where the road surface was less than 1 foot above the high-water level of the river.

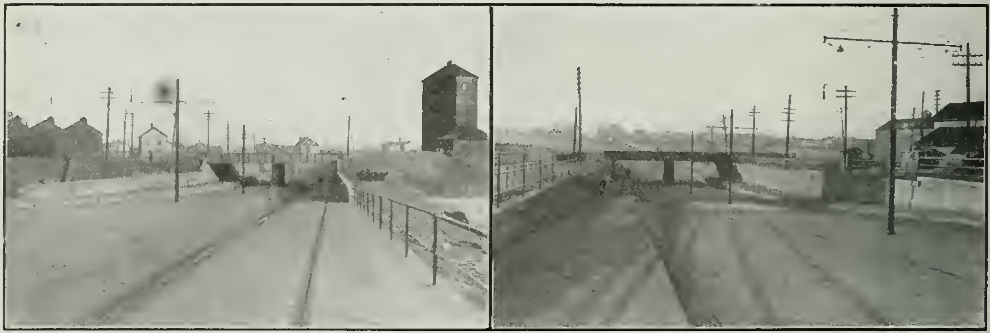
The total cost of construction of the subway amounted to about $130,000, of which the cost of bridgeworks for the C.P.R. tracks was about $38,000.

There were some 22,500 cu. yds. dry excavation moved at about 60 cents per cu. yd., 2,000 cu. yds. of wet excavation at $2.60 per cu. yd., 5,000 sq. yds. of brick paving, which cost about $54 per 1,000 delivered on the site. These paving bricks were obtained from Denver, Colorado, and the price laid on 5-in. concrete base and 1½-in. sand cushion was about $3.50 per sq. yd.

The work was commenced in May, 1912, and completed in October, 1913, being closed down for about five months during the winter. However, practically all the excavation had been completed and sufficient progress made to allow of a good roadway being left open for both vehicular and pedestrian traffic throughout the winter.

The subway forms the main thoroughfare between the north and south of the city, and has, therefore, been so constructed that although subject to continuous heavy traffic the cost of maintenance should be small, and at the same time the initial outlay has not been excessive.

The plans were originally designed in 1911 by Mr. J. M. Wilson, then city engineer, and Mr. R. G. Saunders, his assistant city engineer, being revised by Mr. Antonisen, the city engineer in 1912, and the work carried out by Messrs. Wilson, Townsend and Saunders under the supervision of a member of the city engineer's staff, Mr. B. C. Ward, as resident engineer. Mr. Geo. D. Mackie is now city engineer and commissioner, and to him we are indebted for the above information.



Subway at 11th Avenue, Moose Jaw, Under the Canadian Pacific Railway Tracks.

GRANITE IN BRITISH COLUMBIA.

An important matter to Vancouver is the discovery on Texada Island, 50 miles from the city, of an inexhaustible ledge of mottled ganite. Some of the stone was, says an American consular report, quarried experimentally, and the polished slabs used in the new Victoria Theatre. A $150,000 company has leased the ledge from the Government, and will develop the quarry, building a gravity tram line to the water edge, whence the stone can be transported cheaply to Vancouver for dressing. During the past five years over $3,000,000 worth of marble has been imported into Vancouver for interior work on new buildings. In the future most of the stone for such work will be quarried in British Columbia.

SEWAGE DISPOSAL IN EUROPE.

It is obvious that sanitary engineers of this continent have decided advantages in being able to glean from the European types of sewage disposal works those features that are best and most efficient for use in this country. Proper combinations and adaptations of English and German types, together with whatever improvements ingenuity may suggest, should produce sewage disposal works of the highest order, there being no prejudicial feeling for one type and against another, such as exists in Europe.

A brief review of sewage disposal works in some of the European cities is given by Geo. E. Dalesman, principal assistant engineer, Bureau of Surveys, Philadelphia, in a paper recently presented to the American Waterworks Association. The following observations are conducive to a general understanding of the disposal situation in Europe as it appears to the interested observer:—

The use of underground channels to carry off the liquid wastes from dwellings is a very ancient practice. In the beginnings of ancient Rome there were built large conduits, in use to this day. On the Island of Crete, the home of the Aryan progenitors of the ancient Grecians, recent excavations show that underground drainage channels were systematically constructed at least 3500 years B.C. The construction of these channels as a system, however, may be said to have begun in the nineteenth century.

Scientific and effective treatment and disposal of the liquid wastes was discussed in the last quarter of the nineteenth century, experiments inaugurated and many works constructed during that time; but during the early years of the present century the art has made much progress, works have been built in accordance with the most successful lines of experiment, and many additions made to the earlier works.

Sanitation. — While sanitation comprises many branches, that represented by the term sewage disposal is one of large influence upon the general health of a community.

Prior to the introduction of sewage systems in large cities, death rates were high, and for centuries at intervals of a few ears or decades, their populations were swept away by plague or pestilence, fostered and spread by admixture of noisome liquid wastes with the drinking water. Repetitions of these visitations were accepted as natural, until modern science showed that by the introduction of proper systems for carrying away liquid wastes the mortality could be lessened. Striking examples are the city of Havana and the Canal Zone, made habitable and safe by the introduction of sanitary conveniences.

Municipalities, especially in the crowded European centres, took up the matter of improving old conditions with vigor, full-size experimental installations were made, gradually developing into complete systems for the collection and disposal of the sewage.

The agitation for better sanitary municipal surroundings has given rise to keen debates, and has set up many champions of a radical change, calling for the exclusion of sewage matters from streams and rivers.

Calmer judgment and extensive experiments have tempered these views, until at present it is recognized that the streams themselves are, and have been, effective agents in transforming organic or putrescivle matter into a mineral or innocuous state up to a certain limit, dependent upon the amount of available oxygen in the water.

European Conditions.—The examinations of sewerage systems in European cities are valuable on account of the concentrated population and the results achieved by the introduction of sewage treatment systems in lowering their death rates, even with a water consumption of from one-fourth to one-sixth of that in American cities. This, resulting in a far more concentrated sewage, calling for different treatment than our own, necessitates also the treatment of a volume of storm water when polluted by the sewage, ranging from four to six times the dry weather flow, a condition which does not arise with our more dilute sewages.

By reason of their concentrated populations and the smaller size of European rivers, with their small diluting volumes, the urgency of installing sewage treatment works has been greater, to protect their restricted water supplies and to avoid nuisances that would in some cases make their cities noisome places of abode.

Again, on account of their nearness to Asiatic cities, the homes of plague and pestilence and their open harbors, sanitary safeguards are essential.

Owing to restricted parking areas and the possibilities of river embellishment, by the removal of sewage pollution, they have been enabled to make of their rivers the most attractive features of their cities, for bathing and the enjoyment of people in their hours of relaxation.

American Conditions.—The American cities have grown rapidly from villages, and the village practice of building a culvert to the nearest stream has until recent years survived. The drains from various villages have grown into a system with many outlets discharging crude sewage into the larger streams.

Large streams like the Schuylkill River, suitable for water supply, have gradually been eliminated from the lists of available sources, the rivers themselves have become septic tanks, and of recent years, even rivers like the Delaware and Hudson have been polluted, so as to require effective treatment before their waters can be used for domestic consumption, a prodigal waste of natural resources.

A few years ago the old-fashioned cesspool was in vogue, and we can remember when protests were filed against the building of sewers. Now, since no block of dwellings can be disposed of without them, builders solicit drainage facilities as the first step in the improvement.

A few years ago black, dirty, sewage-polluted water was consumed by local residents without question, and affliction with enteric diseases in consequence was taken as a matter of course. The improved water supply has educated our people to other views.

In port operations, formerly, any filth could be thrown from vessels or dumped into the river. To-day it is recognized that to compete for the world's commerce we must remove from sight and smell all nuisance.

To-day pollution of water supplies will not be tolerated, and a reduction in the deaths due to preventable disease appeals so strongly, that the great insurance companies have banded themselves together, with millions of capital behind them, to study their causes and remedies with a view to stamping them out.

We are just learning to be less prodigal and to devise ways and means to conserve our advantages, to protect our streams, to be dissatisfied with their pollution with sewage; but it will take some educational campaigning before the people at large will understand the value to the communities of sewage treatment.

Advances in the Art.—The advance made in the art, due to large sums spent in full-size experimental installations, in efforts to free natural watercourses from pollution, has been steady and positive, each forward step

taken after experience in operation or research warranted it.

In the first instance, farms irrigated with sewage were operated, but this practice has been abandoned, except where by reason of the great cost of the installation, it is not practicable to change the treatment.

Screening and tank treatment, sometimes coupled with sand filtration, have been substituted in some instances.

Throughout England, where rivers are comparatively small, plants are undergoing reconstruction, and some form of bacterial treatment in beds is being added to the preliminary treatment. In some cases it has been found to be economical to turn the earlier works into scrap and build entirely new as at Leeds.

In English sewage disposal plants, the disposal of sludge, except where it is carried to sea, has been generally inadequate. This is now considered by many the most vital problem.

In Germany, by several processes the problem of sludge disposal has been successfully solved.

As to the present status of the art the following statements may safely be made:—

Sewage even of exceptional concentration can be effectively treated, so as to secure a clear, odorless, sparkling, non-putrescible effluent before discharging into a stream, the securing of which is a matter of cost, and, therefore, an economic as well as a constructive problem.

Sludge resulting from sewage treatment can be rendered innocuous, practically inodorous, wholly unobjectionable, after which it may be dealt with in various ways.

Desired results may be secured by certain combinations of treatment at a fraction of the cost of other recognized scientific methods of treatment in satisfactory operation.

Relation to Water Supply.—It is considered by some eminent sanitary engineers that they are justified in placing sewage disposal next in importance to water supply in the list of public utilities. This is based upon the value of protecting the streams from nuisance, to conserve sources of water supply and to protect the health of the people.

As a water supply is taken from a river, its application to a populous community produces sewage, and, as its natural destination is a return to the stream, used possibly again for water supply, it gives rise to an economic problem as to the proportionate share which should be borne in the treatment of both the water and sewage.

The theory of excluding all sewage from return to a stream, held some years ago, is untenable, and with this recognized and the necessity of utilizing the diluting volume of the river and its available oxygen to continue the treatment begun in disposal works, the problem resolves itself into an economic one.

The uses to which the waters of a river are to be applied are controlling factors in the standard of effluent to be secured.

The comparative economy of treating sewage to a high degree of purification or of taking a lower standard and increasing the degree of water treatment, must be solved by each community.

When comparing the amounts of available chlorine required in water and sewage effluent treatments it has been found that of three turbid raw water supplies, the average amount of available chlorine required to render the manufactured product free from bacteria resembling B. Coli is p.p.m.: of three other raw surface waters, 0.3; of four examples of sand filter effluent, there were required 0.33.

For the effluent of sewage works under average conditions, which had been subjected to settlement, there were required 6 parts; that which had passed percolating filters, 3 parts, and that which had in addition been subjected to secondary settling, 2 parts.

In general, therefore, it is cheaper to treat water when practical disinfection can be secured by the admixture of from 0.3 to 0.7 p.p.m. of available chlorine instead of attempting to secure an uncertain comparative result in the treatment of sewage effluent by the admixture of from 2 to 6 parts, with a probability of having to resort to an equal amount of treatment for the water notwithstanding the sewage treatment.

In Germany, with its concentrated populations, rivers are considered by the rivers boards as proper places for the disposal by dilution of sewage submitted to fine screening and settling tank treatment, from which rivers are taken the water supplies usually from driven wells or filter galleries along their banks.

Judging from the exceptionally low typhoid death rates in these cities, any condemnation of the practice must be supported by arguments from other sources.

Grit Chambers.—Frankfurt, Huddersfield. Sewage reaching treatment works from a combined sewer system must be subjected to passage through a grit chamber to remove sand and coarse gravel. This is accomplished by an increased flow area, to reduce the velocity to 15 inches per second or less. The types in use in Frankfurt, Dusseldorf and in the Emscher district are good examples. Deposited solids are usually removed by elevator bucket dredges having transverse motion on tracks. This admits of operation without putting the grit chamber out of service.

Screens.—Hamburg, Frankfurt, Dresden, Bolton. Screening in England is for the purpose of removing such solids as would clog pumps or would be not readily reduced in tank treatment; therefore, it is coarse screening, the bars being spaced about 2 inches.

In Germany, however, it is considered in many places as a complete and efficient treatment; therefore their manufacture and maintenance have received much more attention. Usually there is a coarse screen of about 3 inches spacing composed of bars to protect pumps or valves. The screening processes proper consist in the main of three types designated as Hamburg, Frankfurt and Dresden.

The Hamburg type consists of a curtain inclined at an angle running over drums, brush-cleaned. The apertures of the screen are about 3/8 inch. Where there is a large tidal range and fluctuating depth in the sewers, this is most effective and can be operated with slight nuisance although it is cleaned by brush with difficulty.

The Frankfurt screen consists of five vanes cleaned by a comb, the prongs of which alternate with the spaces of the screen. The combings are passed to a table, which disappears under a knife edge, the scrapings going to a belt, the screen being easily cleaned and very efficient.

The Dresden screen, introduced in about fifty European plants in Germany, Austria and Russia, is the most improved and simplest in its operation. The cleanliness that can be maintained is hard to believe unless seen, being entirely without nuisance or objectionable features. The spacing is about 1-12 inch. Its efficiency will average over 50 per cent. solids removed. Screens, however effective, cannot compete with properly designed tanks.

Tanks.—Frankfurt, Birmingham, Essen 2. Without entering into the comparative merits of settling, septic, sedimentation, Emscher or other forms of tanks, a number of types are shown.

Where the sizes of rivers and the consequent dilution is large, and water supplies are not jeopardized, the rivers

boards of Germany have after examination pronounced fine screening of sewage a sufficient protection of the rivers.

Where smaller rivers must be used for final disposal or water supplies must be protected there is added some form of tankage treatment.

Septic tanks as at Wilmersdorf deal with a concentrated sewage, are foul smelling, though the final effluent is satisfactory.

In sedimentation tanks as at Frankfurt, each unit has a storage period of one and one-half hour; cleaning is resorted to once a week. The type tank involves the placing of a unit out of service when being cleaned, resulting in odors noticeable underground at 150 feet distance.

Throughout England the septic tank is in use designed for storage periods of from twelve to twenty-four hours.

The difference between the German practice of about two hours and the English practice of eighteen hours' storage, calling for from five to ten times larger tankage area, is due to the smallness of the English rivers and the necessity of taking out as large a percentage of solids as practicable.

Methods of cleaning tanks of deposit are various, that at Bolton consisting of a squeegee having considerable merit.

At Frankfurt the sloping sides and bottom enable the sludge to flow to a central sump, whence it is pumped to centrifugal dryers.

Compare the area of the tanks in Birmingham (12 acres) for 900,000 inhabitants with that of Essen Nord (½ acre) for 190,000, which illustrates the difference in area as given above, required according to the practice in these two countries.

The so-called two-story tanks, called Emscher tanks because used in the Emscher district, are twofold in their operation. They provide a sedimentation chamber for about two hours' storage, and a digestion chamber for sludge, there being a diaphragm to separate the liquid from the solid parts of the sewage. The gases generated by the decomposing sludge do not pass through the sedimentation chamber; therefore the liquid remains fresh as distinguished from septic or smelly sewage. The biological processes carried on in the digestion chamber successfully mineralize the sludge, so that when withdrawn, usually by hydraulic pressure, due to difference in head between tank water and sludge outlet, the product is without objectionable odor, and is like garden soil, suitable for filling in low ground if not utilized for fertilizer.

The tank can be cleaned without placing out of service, and is to-day on many points the most efficient type in use.

Tank treatment, even with long storage periods without supplementary treatment, is not sufficient to prevent extreme pollution of the small English rivers, whereas with the larger German rivers, it is efficient, with short storage periods.

Contact Beds.—Sheffield. A form of bacterial bed in use largely in England and America is the contact bed, consisting of a basin enclosed by walls, filled with cinders, fine stone or other materials, into which sewage, usually after being submitted to tank treatment, is admitted slowly, allowed to stand some hours, then slowly emptied, and allowed to stand empty for some hours, the oxygen admitted during the withdrawal of the liquid serving to provide food for the bacteria acting upon the solids attached to the surface of the material in the bed. The so-called slate beds may be so classed because of the similarity of operation.

Two good examples are at Manchester and at Sheffield, the first caring for the sewage of about 250,000, the latter of about 470,000 inhabitants.

The process is regarded as effective, but as the amounts that can be treated are small, about 500,000 gallons per acre per day, about one-fourth of the amount which may be treated in other more rapid processes, percolating filters, for example, with a consequent larger area and larger maintenance charges, more intensive processes are talked about, but as much capital is locked up in such large plants it is difficult to make radical changes.

Percolating Filters. — Wilmersdorf, Birmingham, Huddersfield, Bolton, Salford. Percolating filters consist of beds of cinder, broken stone, gravel or other hard material, thoroughly underdrained, upon which the sewage, subjected to preliminary treatment, is applied by some form of distributor, usually to spray the liquid; rotating arms, longitudinally travelling trough, fixed nozzles, or by means of a network of perforated pipes laid on the surface of the filter. With the exception of the circular filters, 65 in number, at Wilmersdorf, near Berlin, with rotating arms, and a few small scattered examples there are none of these beds in Germany, although experimental installations have been in use, and their ultimate use is forecasted, notably in Hamburg and Leipzig.

An experimental station of large size has been in operation in connection with the work at Paris, France, as a result of which the speaker was informed by M. Verrière, the chief engineer, that in the forthcoming report for the remodelling of the system percolating filters would be recommended in place of the existing farms.

In England the use of the percolating filter is most extensive, not as a matter of choice, but from necessity.

The prevalence of cities with large populations, and the many manufacturing villages forming a chain between, with the comparatively small sizes of the rivers and the great amount of pollution which reaches them, in some cases equalling their flow volumes, have forced more complete treatment of waste liquids than can be obtained by screening and tank treatment alone. This is especially the case in the manufacturing sections, Warwickshire, Lancashire and Yorkshire. Ten years ago it was the view of Sanitary Engineers that septic tanks would reduce and liquefy 90 per cent. of the sludge deposited in them; now it is known that between 10 and 20 per cent. is the average reduction.

Within twenty years millions of pounds sterling have been expended upon works, but some are being consigned entirely to the scrap heap, as at Leeds, many others are being planned to supplement present treatment by percolating filters, and many are in a process of alteration.

When it is considered that by resorting to these filters the rate of treatment for English sewages can be doubled over the best contact bed system, the matter of area of ground and construction cost alone shows economy.

With strong English sewages composed largely of manufacturing wastes, there is considerable odor from these spraying filters. The small white moths or flies that infest them are an intolerable pest. Experience shows that this nuisance is greatly reduced by surrounding the filters with close stone walls and placing a fine surface medium.

Sludge Disposal.—Of all matters reaching a sewage treatment plant, that of proper disposal of the sludge, or residue from tankage treatment is the most serious. A dozen plants can be named, the efficiency of each of which from an operating standpoint is unquestioned, with the single exception of sludge disposal. The methods of disposal vary with the local conditions. They comprise,

irrigating on farm land, underdrained lagoons, burying in trenches, pressing and drying, centrifugal drying machines, briquetting and burning, canal boats to farms, steamer to sea, digestion in tanks and drying on sand beds then used for filling.

The effectiveness from the standpoint of lack of nuisance about the works is as follows: (1) digestion, drying and filling, (2) steamer to sea, (3) drying under heat. The remaining methods are ineffective.

1. The speaker has stood in the centre of a 6-acre tract of air-dried sludge, 50 per cent. moisture, of depth varying from 3 to 12 feet, in damp weather, without detecting any more odor than would be noticed from a freshly ploughed unfertilized field. Example—All over the Essen district.

2. Pumping to steamer and disposal at sea is positive in the removal of all nuisance except during cleaning of tanks. Examples—London and Manchester.

3. During cleaning of tanks and during drying by centrifugals, it is smelly within the building; after drying by heat, there is no further objectionable odor. Example—Frankfurt a. Main.

It may positively be asserted, therefore, that with certain treatments the sludge problem is satisfactorily solved.

When sufficient fats are present in the sludge (about 25 per cent.) they may be profitably recovered as at Bradford.

Notable Treatment Works.—Notable as being the best of their kinds are the following works:

Hamburg—Grit chamber screening and dilution in the Elbe.

Dresden—Grit chamber and fine screening with dilution in the Elbe.

Vienna—Efficient collecting systems with dilution in the Danube.

Frankfurt a. Main—Grit chambers, screens, settling tanks, sludge dried in centrifugals, further dried by heat and burnt under boilers to produce electric current.

Wilmersdorf—Primary settling tanks, percolating filters, secondary tanks, sand filtration, sludge in lagoons.

Cologne and Dusseldorf—Fine screening and tankage, with dilution in the Rhine.

Berlin and Paris—Farms.

London—Screens and tanks with dilution in the Thames, sludge to sea.

Manchester and Sheffield—Screens, tanks and contact beds.

Birmingham—Detritus tanks, settling tanks and percolating filters, sludge to lagoons.

Salford—Grit chambers, settling tanks, roughing filter, percolating filters, sludge mixed with chemicals, pressed and dried.

Many others will outclass these when new works shall be in operation.

River Fronts.—One of the most noticeable results of the establishment of sewage disposal works, is in the ability to improve and embellish river fronts.

In London not many decades ago the stench from the sewage polluted Thames invaded the Houses of Parliament and pleaded the cause of sewage treatment. The cleaning up of the Seine at Paris, the Spree at Berlin and other rivers was accomplished only after centuries of warning sounded by the periodical visitation of pestilence. River nuisance has been successfully avoided in European cities by the construction of interceptors along the river banks.

Lessons.—The choice of a certain process can not be made because of its reputation for effectiveness, but the design must be determined upon only after all phases of the local conditions are considered, starting with the characteristics, size and volume of the river into which final disposal is to be made, and adopting the most economical system, the effluent from which will not unduly overload the river, and which will utilize the available diluting capacity of said river, or parts of a river.

The lessons learned from an inspection of European cities may be briefly summed up as follows: Collecting systems are designed with the most minute attention to economy, therefore along scientific lines.

The quality of material and workmanship in sewer construction are superfine, due in a measure to mechanics' wages being one-third of ours.

For the best developed screening appliances we must look to Germany.

Tanks, both on account of economies in areas and scientific design for construction and operation have been developed to a better standard in Germany than elsewhere.

Percolating filters, and the operation thereof may be best studied in England. Scientific experimentation on this system has been more thoroughly carried out in Paris.

The investigations upon river dilution have been carried on more thoroughly in Germany.

Sludge disposal, except where it is carried to sea, has not been solved in England. In Germany, it has been satisfactorily solved by several methods.

The English sanitary world is hopeful that we are on the eve of developing a more intensive, economical and effective means of treatment than the percolating filter.

The engineers in charge of the new "third lock" at the Soo Canal in Sault Ste. Marie, Mich., have predicted that before the end of the month, this lock, with a length of 350 feet greater than any other lock in the world, will be open to navigation. The new lock has a total length of 1,350 feet, a width of 80 feet, and a depth sufficient to permit boats of 24-foot draft to pass through it. With the locks already in operation at this point, the new lock will permit a gross tonnage to pass through from the waters of Lake Superior to the lower lakes that is ten times greater than the expected annual tonnage of the Panama Canal. Three locks are now in operation in the canal, two on the American side of the St. Mary's River and one on the Canadian side. Two additional locks are under construction on the American side, one being that known as the "third lock."

The display of Canada's natural resources at the Canadian National Exhibition this year will be a record in its completeness. The farm, the forest, the mine, the fisheries and the sources of other industries will be depicted in a most comprehensive manner. The federal and provincial governments are preparing extensive exhibits.

The Dominion Creosoting Co. (Limited), of Vancouver, has received from the Bengal and Northwestern Railway Co. of India an order for 160,000 creosoted railway ties. The specifications call for the best quality of seasoned Douglas fir, to be treated with 12 pounds of creosote per cubic foot, under specified temperature and pressure conditions. If the Douglas fir ties prove satisfactory for railway construction in India it is probable that other large orders for similar supplies from British Columbia will follow, and the creosoting industry of the province will be given a decided impetus from India.

The loss sustained by the G.T.P. Steamship Co., in the fire which destroyed recently the company's pier at Seattle, Wash., is estimated at $350,000. Damage was also done to the Coleman dock, both the pier and dock being located in the very heart of the Seattle waterfront, which brings the total estimated damage caused by the fire to about $500,000.

VOLUME CHANGES IN CEMENT AND CONCRETE.

PROF. A. H. WHITE, of the University of Michigan, has carried out a scientific investigation, covering many years, into the changes that Portland cement undergoes after hardening in water and being alternately exposed to wet and dry. Three years ago he presented a paper on the subject before the American Society for Testing Materials. Since 1911 he has continued his experiments, to find his earlier results confirmed. Further, it has been shown that the destructive action of these forces of expansion and contraction may be even more serious than was previously thought probable. Prof. White's later results formed the basis of a paper which he read recently at the 17th Annual Convention of the Society. His paper is a continuation of the preceding paper, and discusses the effect of high and low temperatures in addition to the effect of varying moisture. The results are dealt with in detail, and form an extensive treatise. A summary of them are given below:—

The tests confirm the theory that Portland cement in reacting with water forms a colloid which expands when wet and shrinks when dry. It does not become irreversible and lose this property, even after 20 years' exposure to the weather or after heating to 600° F. The length of a bar which has passed through a cycle of drying and wetting is not usually the same as it was before the cycle, but may be longer or shorter. Under ordinary conditions the bar remains elongated because water acts more rapidly, and the compressive strength of the expanding colloid is more than the tensile strength of the contracting colloid. This is especially true in concrete or in mortar where the particles of aggregate forced apart by the expansion lock in their new positions so that the bar remains permanently elongated. With neat cement, where the only aggregates are the unattacked particles of clinker, the bar may be made to grow shorter. By suitable alternations at elevated temperatures a bar of neat cement has been made to shrink in length 4.6 per cent. and under identical conditions, a bar of 1:3 sand mortar to elongate 0.75 per cent. Bars sawed from a sidewalk taken up in good condition after 20 years' service were made to attain a further elongation of 0.175 per cent. for the top coat and 0.130 per cent. for the base after a series of prolonged wettings and dryings at room temperature. This is an expansion equivalent to that which might be expected from a temperature variation of 300° F.

Concrete which has been properly made, and in which the colloid has been properly developed, has its interstitial spaces so filled with dense colloid when it is thoroughly soaked in water that there is no liquid water present in the pores. Such concrete may be frozen without any expansion. In fact, it will contract with temperature change at almost exactly the same rate as cast-iron. If the concrete has been poorly prepared or if there has been insufficient opportunity for the cement to develop its colloid by reacting with water, then its pores when wet will contain liquid water which will expand as usual on freezing, with possible resultant disintegration.

Concrete kept constantly wet from the time it is poured will expand rather slightly, and after a few years will be practically in equilibrium with its surroundings, and will not suffer further change since the pores have become filled with a dense colloid, which prevents water from acting on the unchanged cement. Such concrete will contract at low temperatures at the same rate as cast-iron, but will otherwise be unaffected by freezing, and may be considered a permanent structure. It will be in compression throughout because of the development of the colloid and will, therefore, be strong. The slow development of the colloid of the cement in contact with water explains the decrease in leakage frequently shown by dams and reservoirs after they have been put into service.

Concrete which is allowed to dry soon after it is poured, and which thereafter remains exposed to the air but protected from rain, will be weak because its colloid has been insufficiently developed. Further, it will—if its ends are restrained—be in tension because it shrinks as the colloid becomes dehydrated. Even this concrete will, however, react with the moisture of the air and will probably gain strength in the process, so that concrete used in the interior construction of buildings will probably meet its severest test within the first few months after it is poured. Concrete of this type will nevertheless have a relatively poorly developed colloid and will be porous. If it becomes wet and freezes, it will expand and the expansion may be permanent.

Concrete which is exposed to the weather is put to a very severe test. It expands and contracts when alternately wet and dried, and probably retains this property indefinitely. It has no stable condition, but is always slowly changing. The changes are progressive, especially where the concrete is occasionally kept thoroughly wet for perhaps a month at a time. This period is sufficient to cause the colloid to expand quite fully. At first the only effect is to make the concrete more dense and to fill up the pores. After several years the mass begins to expand as a whole. The particles of gravel are forced apart, and, wedging in their new positions, fail to return when the concrete dries again. The next time the concrete is wet an added quantity of water enters and reacts with still unchanged cement, with the result th[illegible] is larger expansion. This progressive elongation is the cause of the pressure ridges and upheavals found frequently in old cement sidewalks. It has been shown in this paper that sidewalks after 20 years' service still possess this capacity for further progressive expansion. This phenomena is, of course, more serious in damp climates than in dry ones, and in moist locations than those which are well drained. The author has seen cement sidewalks in exceptionally well-drained situations which showed very little signs of deterioration after 20 years of service.

When concrete dries the surface dries relatively rapidly and the shrinkage is considerable, especially if it is rich in cement. This shrinkage of the surface while the rest of the structure is still wet and expanded causes hair-cracks to appear on the surface, even when the unit is small and entirely unrestrained. Each subsequent expansion and contraction will cause this hair-crack to deepen. The disintegrating effect will undoubtedly be accentuated by impacts such as concrete highways receive from traffic.

The changes of volume due to moisture are more apparent with mixtures rich in cement than with lean mixtures. In sidewalks and pavements it would, therefore, be expected that the rich top coat would expand and contract to the greater extent. This is frequently the case, and its results may be seen in sidewalks where the top has split off the base, due to differential expansion. However, the rich mixture with its greater tensile strength tends to contract to its original length more perfectly than the mixture with less cement and more gravel, and in pavements and sidewalks the leaner base is buried in the ground, where it remains wet for a longer period. Under proper conditions, therefore, the base may ultimately expand more than the top coat and give the concave effect to a walk or pavement which is not infrequently observed.

Frost is not much to be feared as an initial instrument of disintegration of properly mixed cement which has been given a fair chance to develop its colloid, since the amount of liquid water in the pores of the concrete is too small to cause serious expansion. If disintegration has started from other causes, water may enter in larger quantities, and on freezing may cause serious injury.

If concrete, and particularly rich concrete, is to remain exposed to the weather, the only way to keep it in good condition is to so place it or protect it so that it will not be subject to great fluctuations in its moisture content. The most trying conditions are those which concrete highways have to meet. As pavements are now being laid, they seem certain in many localities to prove a serious disappointment to those who are building them with the expectation that they will be permanent structures.

MONTREAL TRAMWAYS' GOOD REPORT

A good report has been presented to the shareholders of the Montreal Tramways Company, it having earned over 30 per cent. on its stock, while showing substantial increases both in gross and net earnings. For the year ended June 30th, the gross earnings showed a gain of $388,577, or 5.7 per cent., and the net earnings an increase of $215,127, or 7.9 per cent.

The following table compares the chief items of the reports of the two years:—

	1914.	1913.
Gross earnings	$7,142,804	$6,754,227
Expenses	4,206,114	4,032,664
Net earnings	$2,936,689	$2,721,562
Less—		
City's percentage of earnings	527,383	489,079
Bond interest	787,768	721,151
Debenture interest	800,000	800,000
Taxes	84,700	73,000
Leaving—		
Net income	$ 736,836	$ 638,331
Dividends	242,056	156,382
Surplus	$ 494,780	$ 481,949
Reserves	275,000	223,670
Bond discount	82,236	63,714
Net surplus	$ 137,543	$ 194,564

The company's net income was $736,836 for the year, after payment of the city's percentage of earnings. Interest charges and taxes were $98,505, or 15.3 per cent. higher than the previous year. On the average paid-up capital stock for the year this represented earnings at the rate of 30.4 per cent. After dividends had been paid, a surplus balance of $494,780 remained, or $12,831 more than the previous year. From this balance $275,000 was transferred to reserve funds and $82,236 was applied to write off discount on bonds sold.

The balance sheet reveals an advance in current liabilities from $1,475,995 to $1,646,238, with a decline in current assets from $3,725,925 to $1,893,482. This is explained by the fact that new construction was undertaken last year to the extent of about $1,000,000 more than was originally intended, while in the previous year the company had a large sum credited to its account with its bankers against the projected sale of bonds covering plant additions. As expenditures have now been to an amount in excess of $1,000,000 for which the company has the right to issue bonds or stock, the liquid position can be strengthened by the sale of securities at any time.

The company reports that during the year the sum of $2,711,572 was expended on new construction, against $976,008 the previous year; the sum of $829,706 was also expended on maintenance and charged to operating expenses while a further amount of $417,124, charged to renewal account also went towards the upkeep of the properties.

A SWISS REINFORCED CONCRETE ARCH BRIDGE.

An arch bridge which shows the fine architectural possibilities of reinforced concrete is in course of erection near Langwies, Switzerland, for carrying a metre-gauge electric railway over a valley. The general elevation of one-half of the bridge is shown in Fig. 1, the dimensions being in metres. The main arch is 100 m. (328 ft.) in span between the centres of the rib at the springings, and it was only after a considerable amount of discussion that the Swiss Railway Department allowed the use of reinforced concrete for a span of this magnitude; the rise is 42 m. (138 ft.), and on each side of the main span there are four spans of 16 m. (52 ft.) The arch was designed as an elastic hingeless arch, the platform girders approach spans being treated as continuous beams, expansion joints being provided at the top of the double pillars. The central span comprises two separate arched rings, the thickness of which is about 7 ft. at the crown. The width of either rib at the top of the crown is 3¼ ft., and being battered lengthwise it increases regularly from crown to springing. The two arched rings are tied together by means of rigid cross-beams.

The main girders of the outer spans are constructed in the form of beams with a varying moment of inertia, and are connected with their supports in such a manner that a certain amount of movement is possible. The bearing-plates at the points of support of the pillars of the outer spans have been reduced to a narrow margin of area, with the view of ensuring a hinge effect.

The construction of the viaduct has been designed from the point of view of ensuring a maximum saving of material and a minimum as regards actual stresses. This was rendered more possible owing to the live load on the bridge being a comparatively light one in proportion to its dead weight. This also explains the application of two cross-tied arched ribs instead of a monolithic ring, although the latter form has also been carefully taken into consideration. The stress calculation of the viaduct has been based on the assumption of a test-load train that comprises two locomotives of 65 tons service weight each (the type of the Rhaetic Railways), and an unlimited number of adjoining goods trucks that are coupled in one direction. With regard to the stress calculation of the secondary girders, viz., the railroad deck and the minor spans, an addition to the above live load of 15 per cent. has been considered. The additional forces that have been taken into account comprise:—

(1) A temperature change of + 15 deg. (Centigrade).
(2) Contraction due to setting — 20 deg.
(3) Braking forces—one-seventh of the total weight of the loading train-axles.
(4) Wind pressure: (a) 20 lbs. per sq. ft. when the bridge is in super-loaded condition; (b) 30 lbs. per sq. ft. when the bridge is in unloaded condition.

The modulus of elasticity has been assumed: $m = 15$.

The safe maximal compressive stress of concrete:

c = 500 lbs. per sq. in.,

providing the dead weight of the bridge is combined with the most unfavorable superload (live load);

c = 640 lbs. per sq. in.,

providing all the secondary and additional forces are taken into account, i.e., temperature, contracting due to setting, braking-forces and wind pressure.

The safe shearing stress of concrete is assumed: s = 60 lbs. per sq. in.

Safe tensile stress of steel for reinforcement: t = 14,200 lbs. per sq. in.,

provided the dead weight of the bridge is combined with the most unfavorable super-load (live load);

$t = 17{,}000$ lbs. per sq. in.,

provided all the secondary and additional forces are taken into account.

The above figures are based upon the assumption that the concrete (that is mixed on the spot and is daily controlled and tested by a Martens' set of registering apparatus) shows the following minimum standard strength after 28 days of setting time:—

2,880 lbs. per sq. in.

when being rammed on the spot in a plastic condition (poured concrete);

3,550 lbs. per sq. in.

when being rammed on the spot in a moist condition.

The peculiar arch-centring is interesting. The upper part of the falsework has been constructed in the form of a fan built up with round timbers obtainable on the spot in great lengths, at a low price and of good quality. This timber scaffolding is supported by three reinforced concrete towers which have been constructed in the form of framework or skeleton towers. These reinforced concrete towers were employed for the following reasons: it was not advisable to obstruct the valley too much by the falsework, as the scaffolding is exposed to danger from floods, and is thus liable to damage at times when the snow melts and the two mountain brooks, which join just on the building site, carry down enormous masses of water and pebbles. For this very reason the erection of a scaffolding composed of uprights was out of the question, and the tower system only was suitable. Timber-work towers would have obstructed the passage more than reinforced concrete towers, and furthermore they would not have possessed the same amount of stability. The substructure and the foundations would in any case have required the use of reinforced concrete, even if timber-work towers had been erected, as the driving of wooden piles was absolutely impossible on account of the nature of the subsoil, which is composed of coarse pebbles and is intermixed with loose blocks.

The total settlement of the main arch had to be reduced to a minimum, and this also was another reason for using reinforced concrete for these towers. When the central arch was closed the arch centring showed a total settlement of, roughly, 1.2 inches, inclusive of .4 inches which occurred through the headpieces of the diagonal struts cutting into the capping-pieces of the stringers.

The erection of the viaduct was begun late in 1912, but at the commencement of the work operations had to be confined to foundations of the abutments, winter setting in before time and causing an interruption of the work for several months. Not before April, 1913, could the work be resumed, and the concrete work of the large arch was completed on October 6th, in 1913. The winter, of course, again interrupted the work, but it was continued this season.

We are indebted to Concrete and Constructional Engineering for the above illustration and particulars.

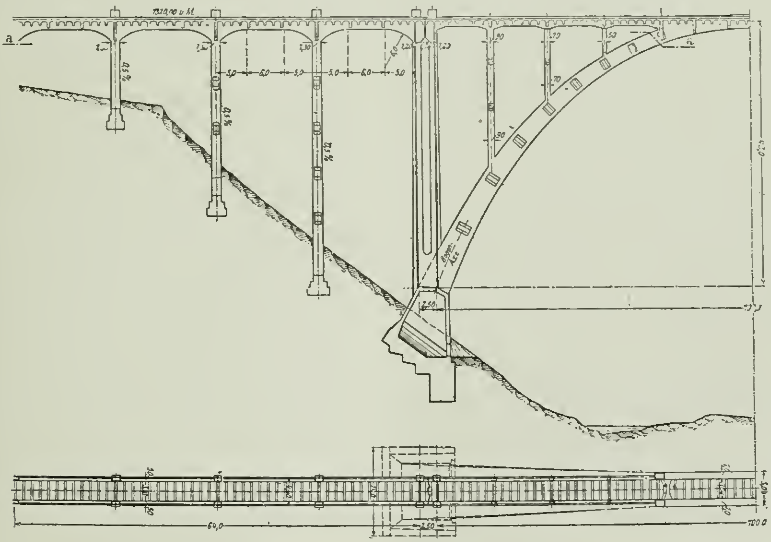


Fig. 1.

Recently the Society of Road Standardization of America sent out from Chicago its first survey in the interest of standardized roads. The road experts engaged upon this initial trip are G. E. Minor, formerly connected with the Old Trails Association, the National Highways Association, and the Indiana Good Roads Association, and H. W. Denis. Their route will proceed through seven states from Chicago to the Pacific coast, the termination of which is to be San Diego, Cal. The primal purpose of the survey is to lay out, map, and log 60,000 miles of the best and most travelled roads in the United States so as to bring to a maximum simplicity the matter of following roads to the destination desired. The society is formed by men interested in the subject of good roads in general and transcontinental highways in particular.

On July 19, the largest electric lamp in the world was lighted and will continue to shed light for some weeks in the New York navy yard. This lamp is a searchlight which has just been installed and is capable of throwing light for a distance of 100 miles. It is called the Beck searchlight, and is the invention of Heinrich Beck, a German scientist, who is conducting tests of his lamp for the United States Government. Measured at 2 miles from the lamp, 450,000,000 candle-power is obtained from a lamp with a 44-inch reflector. The present 44-inch lamp in use on the world's best ships, gives only 60,000,000 candle-power. For coast defence a 60-inch reflector is now in use. Such a reflector hitched to the Beck searchlight gives a billion candle-power, as against 180,000,000 candle-power now obtained.

POLLUTION OF BOUNDARY WATERS.

THE following conclusions relating to water purification and sewage treatment have been arrived at as the result of a conference of consulting sanitary engineers, held at the request of the International Joint Commission in connection with its investigation of the pollution of boundary waters between Canada and the United States. Messrs. George W. Fuller, Earle B. Phelps, George C. Whipple, F. A. Dallyn, W. S. Lea and T. J. Lafreniere are the engineers who participated in the conference, the first three being in practice in the United States, and the second three in Canada. They were submitted a list of questions by the Commission.

The resulting discussion is summed up in the following résumé, which was signed by all except Mr. Dallyn:—

1. Speaking generally, water supplies taken from streams and lakes which receive the drainage of agricultural and grazing lands, rural communities, and unsewered towns are unsafe for use without purification, but are safe for use if purified.

2. Water supplies taken from streams and lakes into which the sewage of cities and towns is directly discharged are safe for use after purification, provided that the load upon the purifying mechanism is not too great and that a sufficient factor of safety is maintained, and, further, provided that the plant is properly operated.

3. As, in general, the boundary waters in their natural state are relatively clear and contain but little organic matter, the best index of pollution now available for the purpose of ascertaining whether a water-purification plant is overloaded is the number of B. coli per 100 c.c. of water expressed as an annual average and determined from a considerable number of confirmatory tests regularly made throughout the year.

4. While present information does not permit a definite limit of safe loading of a water-purification plant to be established, it is our judgment that this limit is exceeded if the annual average number of B. coli in the water delivered to the plant is higher than about 500 per 100 c.c., or if in 0.1 c.c. samples of the water B. coli is found 50 per cent. of the time. With such a limit the number of B. coli would be less than the figure given during a part of the year and would be exceeded during some periods.

5. In waterways where some pollution is inevitable and where the ratio of the volume of water to the volume of sewage is so large that no local nuisance can result, it is our judgment that the method of sewage disposal by dilution represents a natural resource, and that the utilization of this resource is justifiable for economic reasons, provided that an unreasonable burden or responsibility is not placed upon any water-purification plant, and that no menace to the public health is occasioned thereby.

6. While realizing that in certain cases the discharge of crude sewage into the boundary waters may be without danger, it is our judgment that effective sanitary administration requires the adoption of the general policy that no untreated sewage from cities or towns shall be discharged into the boundary waters.

7. The nature of the sewage treatment required should vary according to the local conditions, each community being permitted to take advantage of its situation with respect to local conditions and its remoteness from other communities, with the intent that the cost of sewage treatment may be kept reasonably low.

8. In general, the simplest allowable method of sewage treatment, such as would be suitable for small communities remote from other communities, should be the removal of the larger suspended solids by screening through a ¼-in. mesh or by sedimentation.

9. In general, no more elaborate method of sewage treatment should be required than the removal of the suspended solids by fire screening or by sedimentation, or both, followed by chemical disinfection or sterilization of the clarified sewage. Except in the case of some of the smaller streams on the boundary, it is our judgment that such oxidizing processes as intermittent sand filtration, and treatment by sprinkling filters, contact beds, and the like, are unnecessary, inasmuch as ample dilution in the lakes and large streams will provide sufficient oxygen for the ultimate destruction of the organic matter.

10. Disinfection or sterilization of the sewage of a community should be required wherever there is danger of the boundary waters being so polluted that the load on any water-purification plant becomes greater than the limit above mentioned.

11. It is our opinion that, in general, protection of public water supplies is more economically secured by water purification at the intake than by sewerage purification at the sewer outlet, but that under some conditions both water purification and sewage treatment may be necessary.

12. The bacteriological tests which have been made in large numbers under the direction of the International Joint Commission indicate that in some places the pollution of the boundary waters is such as to be a general menace to the public health should the water be used without purification as sources of public water supply, or should they be used for drinking purposes by persons travelling in boats.

13. It is our judgment that the drinking water used on vessels traversing boundary waters should not be taken indiscriminately from the waters traversed, unless subjected to adequate purification, but should be obtained preferably from safe sources of supply at the terminals.

14. While recognizing that the direct discharge of fecal matter from boats into the boundary waters may often be without danger, yet in the interest of effective sanitary administration it is our judgment that the indiscriminate discharge of unsterilized fecal matter from vessels into the boundary waters should not be permitted.

Mr. Dallyn's revision of the résumé report is not essentially different from the above. He insisted on the elimination of paragraphs 5, 7 and 11, which he considered to be an expression of self-evident facts. He also substituted "monthly" for "yearly" averages in determining the number of B. coli per 100 c.c. of water (clauses 3 and 4).

SHRINKAGE OF ALLOYS.

The excessive shrinkage of brass or bronze alloys necessitates a core which will be crushed readily by the molten metal. Large cores should be made with a soft interior, and this is generally accomplished by filling the interior of the core with cinders, powdered coke, or similar material. The core material must be fine, and this requires the use of finer sands for brass-foundry cores than those usually used in iron foundry work. When a brass casting has been poured and is shaken from the mould, care should be taken to keep the core sand from mixing with the molding sand. The cores for brass and bronze castings are sometimes blown out by shaking out the molds while the castings are still fairly hot, and then dipping the castings in water. The steam generated in the cores blows out the core sand, and gives the castings a better color. Iron castings would be broken by this treatment, but brass castings are rendered softer.—American Machinist

Editorial

THE WAR AND CANADA'S IMPORT TRADE.

The remarkably abrupt quietus which trans-Atlantic commerce received upon the breaking of the war cloud in Europe has been followed by a disturbing indefiniteness as to the duration of the interruption to import trade. In any event, Canadian imports for the year 1914 will be considerably at variance with the uniformly increasing figures for recent years. Last week's announcement of the British naval authorities that the Atlantic routes between England and America were free from danger of molestation by foreign warships is not sufficient assurance for an early resumption of the Atlantic trade other than to and from the British Isles. It is something to be able to send merchandise across safely, but the market conditions at points of destination are considerably more important. Until the war is over and hostilities between the great powers at an end, Canada need not expect that her needs will receive attention, in some European markets at least. Trade with Germany, for instance, is impossible, being stopped completely. In order to continue its present lines of industrial and engineering activity, this country might as well proceed forthwith to look elsewhere for the supplies for which it has been in the habit of paying Germany her good money.

Leaving as unscathed the big bulk of engineering supplies which Canadian manufacturers have provided, and are likely to continue to provide in considerably greater quantities, the remaining needs of national and municipal sustenance and development must be looked after almost entirely by trade with Great Britain and the United States. The latter enjoys over eighty per cent. of Canada's total import trade in engineering supplies. Under present conditions this percentage is likely to increase materially, and Britain's share should undoubtedly do the same. The impression has become prevalent in England during the past week or more that British manufacturers should endeavor at once to secure the overseas' orders which Germany has hitherto had.

The report for the year 1913 of Mr. C. Hamilton Wickes, British Trade Commissioner in Canada and Newfoundland, contains some import statistics that speak for themselves in this respect. The gross receipts of all classes of metal manufactures, machines, machinery, equipment and hardware in 1913 amounted to $198,500,000, an increase of $58,500,000 over 1912. Classifying them and adding percentages, they are as follows, values being given in £:—

(1) Simple Manufactures of Metal.

Source.	Value in £.	Per cent.
United Kingdom	2,410,000	12.7
United States	16,000,000	85.0
Other countries	410,000	2.2

(2) Machines, Machinery and Equipment.

Source.	Value in £.	Per cent.
United Kingdom	1,260,000	8.6
United States	13,160,000	90.3
Other countries	150,000	1.0

(3) Hardware.

Source.	Value in £.	Per cent.
United Kingdom	780,000	12.4
United States	5,160,000	81.8
Other countries	350,000	5.7

Of the gross imports of metals, machinery and hardware, amounting to $198,500,000, those which are classed as "Competitive merchandise" amount to $155,900,000, the United States' share being 83.03 per cent. and Great Britain's, 14.08 per cent.

In connection with this showing, the British Trade Commissioner states: "Only by the share of this trade (Competitive merchandise) which is secured should the efforts of the British manufacturers be judged, and only by these figures should the value of the Dominion market to manufacturers of the United Kingdom be estimated."

With these figures in mind one may venture an opinion as to the effect of the European disturbance upon the general trend of Canadian imports. Evidently the elimination of imports from Continental Europe means an increased demand upon home industries. Second to it, there should be an increased import trade from Great Britain and the United States. For engineering supplies not procurable at home, our cousins to the south will undoubtedly come in for a large share (owing to advantages of easy and rapid access to the market, like currency and similar requirements of customers). British manufacturers will naturally take full advantage of the opportunity now open to supply from her own industries all imports that were hitherto European, and overcome the recognized inconveniences of different standards of manufacture, fluctuation of prices owing to exchange, etc. Obviously, too, better acquaintanceship with the Canadian market and trade conditions will go a long way to minimize the difficulties that one sometimes reads about in the British press. Besides which, the nations which get the business in war time are likely to keep it in peace.

SURGES IN PIPE LINES.

Advancement in the field of hydraulic engineering during the past ten years has been rapid, compared with the history of previous development of this branch of the profession. Turbine efficiencies have been raised from the possible maximum of eighty per cent. to present-day results of ninety-three per cent., or an actual increase of sixteen per cent. in the power which it is possible to derive from any particular development. Runners for a great range of conditions are easily obtained in these times, with specific speeds ranging from ten to one hundred and capacities in single wheels up to almost any horse-power. Hydraulic governors have practically reached the stage of perfection; little more can be asked from the mechanical standpoint for the regulation of water-power plants.

There is one feature of the design of hydro-electric developments, however, that has not progressed with the same rapidity as those just mentioned. We refer to the regulation of the water columns in those plants having long feeder pipe lines and penstocks. For this reason it is with considerable pleasure and satisfaction that we draw the attention of our readers to a treatise on surge tank problems, the first part of which appears in this issue.

Probably the reason for tardy analyses such as this, compared with like investigations in other phases of hydro-electric design, lies in the fact that it is only of recent years that such long penstock lines, with their associated problems, have been installed.

Interest, however, has been aroused to the point of keenness regarding the best method of securing close speed regulation, commercially and economically. A recent discussion in an engineering contemporary, published in the United States, regarding the means used on the Los Angeles aqueduct for regulating the surges due to changes of load on the power plant shows that the methods employed in that instance were far from being economical, at least $200,000 having been spent in excess of what would have been the necessary outlay if another solution to the problem had been applied.

Professor Prasil's work will, therefore, be read with interest and benefit by engineers who have had to do with the design of plants for these conditions. One serious defect in the analysis that will be noted as the discussion continues, is the fact that frictional losses in the pipe or penstock are assumed to vary with the first power of v, instead of 1.8 power or with the square of v, as is actually the case. Evidently the integrations resulting from the use of the correct power have been too difficult for mathematical manipulation and the writer has accordingly been compelled to approximate.

The paper will bear careful study, however, as it throws considerable light upon a most difficult subject, and the translators are to be congratulated upon having put it into shape for readers of English. It is hoped that those who are interested will enter into a discussion of this subject, for as yet far too little is known, or has been published, dealing with the most efficient and proper means of handling the inertia of long water columns.

STEEL CASTINGS FOR THE QUEBEC BRIDGE.

Sixteen grillage castings for the new Quebec Bridge have just been completed. They are worthy of note because they are much larger than any steel castings previously made in Canada. The weight of each is about 43 tons. Each is 21 ft. x 6 ft., 8 in. x 4 ft. in dimensions. Owing to the intricate design of the interior of these castings necessitating a large number of cores the making of the moulds required a high degree of skill and accuracy. The material used in them is a high grade of steel, being scrap metal procured from the wreck of the old Quebec Bridge.

Upon their arrival at the bridge site they will be bolted in pairs, two pairs to each concrete pier carrying the main columns of the bridge.

COMMISSION GOVERNMENT AT EDMONTON.

Following are a number of the clauses adopted by Edmonton as a part of their new commission form of government charter:—

1. That by a two-thirds vote of the electors the charter may be amended without reference to the legislature; except in matters affecting franchises and the borrowing powers of the city.
2. That the commission council shall consist of five commissioners elected at large.
3. That commissioners shall be elected to duties, so that there will be elections to fill the office of commissioner of finance, commissioner of public works, commissioner of utilities, commissioner of safety and health, and commissioner of parks and markets.
4. Commissioners shall be elected for four-year terms.
5. There will no longer be any election for mayor, the commissioners after each annual election selecting their chairman, who is to be called "mayor" from among their own number.
6. Anyone who is qualified to be a candidate for commissioner who is a British subject, is 21 years of age and can read and write English. Commissioners at the time of their election do not have to be residents of the city.

JAPAN'S OIL DISCOVERY.

Not long ago a great flow of oil gushed suddenly from the Kurokawa oil wells in Japan, and has since shown no sign of diminishing in flow. It is not only of such magnitude that it is producing more than twice the volume of all the other wells combined in that empire, but also of great moment in the history of the oil industry the world over, since the oil flow is simply a steady flow, unattended by the pressure, difficult of control, which has always been experienced in similar cases.

A report was made recently by K. Ito, superintendent of the investigation department of the Nippon Oil Company, under which firm the development of the well is being carried out. The company commenced work on the well early in April, and, after drilling through ordinary earth and rock to a depth of some 1,110 feet, a strata, known as the "shell," was encountered at midnight of May 25th. The drill pierced through this shell or crust at a depth of 1,368 feet into what is apparently the lead-bed of an extraordinary deposit. It is from this bed that comes the present flow.

Not only is the manner of the flow from this well most unprecedented, but what is more unusual is the fact that the other five wells of the company located in the same district, which previously required suction pumping, have also commenced a steady, easy flow.

The output was, at first, somewhat difficult to handle, as no provision had been made for such an unusual quantity. A sump at the top of the hill, which had been constructed to receive the flow, was soon filled, and the overflow was conducted down into upper-level paddy fields, where a dyke was quickly erected around the outside of several cho, thus forming a very large sump. This, in turn, was soon filled, and the overflow was again conducted down into the valley below, where another large sump was hastily constructed, enclosing several paddy fields. Four or five other sumps are now being constructed on this lower level, into which the flow will be directed.

The new well has been capped with a four-way head, which has reduced the output from 480,000 to 120,000 gallons per day, and when the sumps now under construction are completed and filled, the flow will again be reduced. The other five wells have had to be checked entirely owing to want of labor to control them.

The company will find no difficulty in utilizing its output to the best advantage. The imperial navy, as well as the imperial railways, are in need of oil for fuel, and this discovery fills a long-felt want. It is the intention of the company to dispose of the greater part of the production in the crude state, refining only that quantity which may be conveniently handled by its refineries at Tsuchizaki.

Of course, where oil is concerned, no definite or positive idea as to the extent of the lead-bed can be ascertained. But American experts, who were engaged by the company to assist the superintendent of the company's investigation department in his examination and tests, are of the opinion that the flow comes from a bed of lead-sand, and will continue for an unlimited length of time.

Trinidad asphalt mastic has been found to be a satisfactory material for lining concrete tanks which are subjected to the action of sulphuric acid. Many other materials were tried, according to the Engineering and Mining Journal, but none were found suitable except the asphalt mastic, which showed no deterioration after a year's test.

Coast to Coast

Mildmay, Ont.—Recently, at Mildmay, the Mildmay Electric Co., Limited, celebrated the inauguration of its new electric power installation in the town.

Sidney, B.C.—At the new industry which has been installed by the Sidney Rubber Roofing Co, Limited, tanks for fuel oil which have the largest capacity of any north of San Francisco, have been installed.

Stratford, Ont.—The new hydro-electric street lighting system was completed and tested in Stratford on July 31. The lamps are strong nitrogen-filled ones and have been pronounced very satisfactory.

Toronto, Ont.—It is stated that it is understood that the Toronto Hydro-Electric Commission will shortly announce its concurrence with the plans of the Ontario Commission and reduce its rates in accordance with the scale suggested by the superior body.

St. John, N.B.—On August 10, the new cable for carrying the telephone business between the eastern and western sides of the harbor was laid. The cable is of special construction, doubly protected in order to ensure its safety on a rough bottom swept by strong currents. It is 3 inches in diameter, 2,100 feet in length and weighs 32,572 pounds. Sixty pairs of 19 gauge wires are carried in the cable, these being entirely for trunk line use between the two exchanges.

Athabasca, Alta.—Of the 258 miles of length of telegraph line between Athabasca and Fort McMurray, upon which, it is reported, work has recommenced, 118 miles were completed last year as far as Duncan's Creek. It is not expected that the work will be completed as far as Fort McMurray this year. Offices will be opened as the line is constructed at Pelican and House River; and operators will be placed in charge at these points. A telegraphic line will also be constructed from Athabasca to Lac la Biche.

Belleville, Ont.—At present, Mr. John Elliott, president of the Belleville board of trade, is chief of a party consisting of other past presidents of the city's board of trade accompanied by an engineer, which is in England examining into the merits of various road-surfacing materials and investigating roads laid therewith. Mr. Elliott is reported to have stated that he is particularly impressed with the Morland-Hughes system of road construction, as shown on the Upper Richmond Road and Putney Heath North, Borough of Wandsworth, and is prepared to recommend the system for Canada.

Victoria, B.C.—On the Pandora Street paving and double-tracking at Victoria, B.C., good progress is reported, and the work is rapidly nearing completion. The street is being paved by sections, and while none of the work is absolutely complete and ready for traffic, the first coating has been laid and is ready for the asphalt in many places. The double-tracking has now been laid over the entire length, with but a few gaps where there has been delay owing to the cement work; and the line will be ready for regular car traffic as soon as the concrete is laid.

Port Arthur, Ont.—The net three months' profit from the operation of the Hydro-Electric Commission of Port Arthur has been reported to the city council of Port Arthur as $12,-803. Details announced for the operation of the system for the last three months state that the gross profits from operating amount to $23,732 from which is deducted the fixed charges representing interest, sinking fund and annual instalments amounting in all to $10,928. The actual revenue which has been gathered by the city official during the period is $43,933, and the operating expenditure for the period was $20,201.

Victoria, B.C.—The E. and N. Railway Company has inaugurated and has commenced service upon 44½ miles of roadbed in British Columbia extending between Parksville and Courtenay. The distance between Victoria and the present northern terminus is 140 miles, and it takes 7 hours to complete the journey. The roadbed is declared to be a permanent form of construction. The steel used is heavy; and concrete and steel trestles span all streams and rivers where bridge construction could not be avoided. There are now over 200 miles of railway in the E. and N. system, a great part of which has been installed since the C.P.R. took over its control some 5 or 6 years ago.

Calgary, Alta.—Manager Director A. W. Dingman, of the Calgary Petroleum Products Company, has issued a statement to the effect that any reports specifying in figures the production of the company's No. 1 discovery well are absolutely incorrect. At present a certain attempt is being made to pump the well, but drilling will have to be carried to a greater depth and the pumping apparatus put in shape before anything concerning the actual production of the well can be ascertained. The company has considerable oil in the first 12,000 gallon tank and a good deal also in the second 12,000 gallon tank, but it is impossible to measure the production of the well yet. However, it is nothing like 250 barrels a day under present conditions. Mr. Dingman said that the drill at No. 2 well of the company has now entered a hard formation and drilling is found to be a little more difficult. This well is 1,560 feet deep.

Montreal, Que.—The new Marconi stations to be constructed by the Dominion Government at Montreal and Quebec, and relative to which it has been stated that plans for the Montreal station are practically completed, will be of the standard 5½ k.w. type. The Montreal station will be equipped for communication with the Kingston and Quebec stations. The apparatus at the present station in Montreal sends messages generally only as far as the Three Rivers station 70 miles away, although it sometimes communicates with vessels more than twice that distance. The Government will build the new stations which will be operated by the Marconi Wireless Company of Canada. The erection of the Montreal and Quebec stations will give the Marconi Company a string of wires capable of communicating, without interruption, from the head of the lakes as far east as Cape Race and Belle Isle. It is not now expected that either station will be constructed previous to next spring, or until the war situation will have cleared.

Nanaimo, B.C.—Messrs. Walter Thomas and A. E. Mainwaring of Nanaimo, B.C., are the joint patentees of a process by means of which gas may be produced in enormous quantities and at a greatly reduced cost. The inventors have in mind an ambitious scheme for the supply of cheap gas for fuel and light for the whole southern end of Vancouver Island; and their expectations are apparently justified by the results of the process as demonstrated in the experimental plant at Nanaimo. The commercial scheme would involve the conveying of gas through suitable mains through great distances as is done already in California, Portland, Tacoma, and Seattle. It is calculated that the installation of a suitable plant for manufacture under the Thomas patents, and conveyance through pipe lines to a sufficiently large number of consumers would place the whole south end of Vancouver Island on a natural gas basis, the estimated charge of fuel and consumers' gas being 50 cents per 1,000 feet. The project, if carried out, will involve the manufacture and distribution of not less than 1,000,000 feet of gas per day.

Hudson Bay, Ont.—Included in the programme of work under way this year at Hudson Bay and Strait and being effected by the Marine and Naval Departments of the Dominion Government, is the locating of 3 wireless stations in

the strait and at the entrance to the bay, so as to give a continuous line of communication from Port Nelson and Port Churchill to the Atlantic; but the construction of these will not commence until next year. The charting of Hudson's Strait is also being done by the steamer Acadia, while other Government vessels are taking soundings and mapping the harbors at Port Nelson, Fort Churchill, and at the mouth of the Nottaway River. Two lighthouses are to be commenced this year, one on each side of the entrance to Port Nelson, while another one will be built on a newly-charted shoal some miles out in the bay. The charting being done at the mouth of the Nottaway River is preparatory to the construction of the proposed railway from there south-east to the National Transcontinental, in connection with the alternative route from Port Nelson across the northern end of James Bay and thence by rail to Montreal, for which last season an appropriation of $1,000,000 was passed by the Government for preliminary surveys.

Edmonton, Alta.—The city commissioners of Edmonton have decided to allow the firm of Sanderson and Porter of New York, and all other concerns intending to submit offers for furnishing power to the city, four weeks from July 21 in which to prepare and submit these, which shall include in the unit prices given the operation and maintenance by the tenderers of the present steam plant as a stand-by plant, the city to retain ownership of the same. To such prices must be added the annual interest and sinking fund incident to the investment of the plant. Also, all firms must submit a statement of financial backing, a certificate or title of lease of the waters and poundage rights, plans, profiles, level covering, the development contemplated, the head proposed to be developed, length of study of the proposed development, and the name of the engineers who will carry out the work; the city to audit all accounts of construction, from the inception to completion; the company to agree not to capitalize by bonds, stock, or otherwise in excess of the actual construction costs; the city to participate in all profits annually over 8 per cent., and the city to have the right to audit all operating accounts as well as to be given power to decide other questions which the commissioner of operation considers imperative in protecting the city's business.

Victoria, B.C.—A report on last month's operations at the Ogden Point breakwater states that such remarkable progress has been witnessed that the foundations of the breakwater were in view at extreme low tide inshore and everthing was in readiness for the commencement of the concrete structure, which will be a huge reinforced wall stretching far out into the harbor. The official statistics for the month of July show that no less than 361,131 tons of rubble were dumped on the site of the breakwater. The actual figures are as follows: core, 22,545 tons; rubble, 338,586 tons. The total rock dumped during the last three weeks of the month exceeded the record month of last year. A grand total of 1,604 tons of granite blocks were also laid by divers during the month just closed. At the present time the operations of the divers are confined to the shore end of the breakwater, where huge granite blocks, weighing anything from 5 to 15 tons each, are being laid in courses; and as the rubble farther out is brought up to the desired level, these courses will be continued seawards. Good progress is also being made in dumping rock at the site of the new piers under construction by Grant Smith and McDonnell. Throughout July a total of 13,332 tons of rubble were deposited; and much faster progress will be maintained now that everything is complete for the shipment of rock from the new quarry at Esquimalt.

Ottawa, Ont.—Tests made recently by the city bacteriologist of Ottawa, Mr. Jos. Race, show that Ottawa River water is four times superior to Ottawa well water in purity. The tests have been made to ascertain whether the supply of water from the river is reasonably safe for drinking and domestic purposes. Mr. Race concludes his report by sanctioning its use as such. Discussion of the report which has been furnished by R. L. Haycock, acting waterworks engineer, to the waterworks committee, on the same question was adjourned until next week when the committee will also make a report to the city council. In the meantime, Mr. John McRae, civil engineer of Ottawa, will co-operate with Mr. Haycock in preparing estimates of the costs of a number of changes which Mr. Haycock suggests in his report. One of the most radical changes proposed is the removal before winter of the concrete beams supporting the intake pipe recently relaid, which, in the opinion of the acting waterworks engineer, will increase the accumulation of ice and frazil and endanger the safety of the intake pipe. An estimate will be made also on the cost of installing an auxiliary electrical pump at the Queen Street West station for use in case one of the hydraulic set of pumps should break down. Further, estimates will be made on the costs of the projects to connect to the 40 and 42-inch intake pipes and to join the two aqueducts at the pumphouse.

Medicine Hat, Alta.—About one-half of the great irrigation canal which has been under construction by the Southern Alberta Land Company for the past 5 years at an expenditure of close to $5,000,000, has been sufficiently completed to hold water; and about two weeks ago water was allowed to flow into Lake McGregor. The entire undertaking is so well advanced that only about $250,000 will now be necessary to complete the system. The work of constructing the canal begins about 22 miles southwest of Gleichen, where a big dam of cement work has been constructed across the Bow River and forms the intake of the canal. From there it continues about 30 miles to Lake McGregor. This lake is about 22 miles long, is formed by the construction of two huge earth dams across what is known as Snake Valley, and is about 40 feet high at the north end and 30 feet at the south; while in places it will be about 2 miles wide. It is estimated that from 3 to 4 months will be required to fill this area for the requirements of the immediate future. From the lake, the canal continues south and east along the Little Bow River, the entire length of the channel being in the neighborhood of 180 miles. The major portion of the work on the east end is now nearing completion, but it is not probable that it will be in readiness to turn into the lower canal until some time next spring. In the construction of this canal there have been some most difficult engineering problems; and some of the heaviest of the work has had to be replaced.

Esquimalt, B.C.—It is expected that an early date will see the completed establishment of the Esquimalt sewerage system. About $60,000 has so far been expended. The municipality was divided into two sections—B and D—for the present sewerage work. Section B empties into the northwestern main, which is the Victoria main outflowing at Macaulay Point. D section enters the sea at the foot of Grafton Street. The contractors for the B section, Messrs. Agnew and Young, had 9 miles of pipe to install, of which they have laid 4½ miles. Most of the light work has been done; and when the rock boring and more difficult excavating for the tunnel through the Macaulay Rocks has been completed—which work is expected to take about 2 months' time—sewer connection will be established for householders through the local sewers with the northwest sewer. City Engineer Rust states that the rock excavation work is proceeding very satisfactorily, and that up to the present the cost has been somewhat less than the estimate. In D section 2 miles of pipe had to be laid, of which 1½ to 1¾ have been

finished. This work will be complete in little over a month. There will for the present be more connection with the D main than with the B section. At the foot of the streets being connected with D section, a rock formation extends along the shore; and here blasting and stone crushing is being carried on, rapid progress being made. On most of the streets the sewer trenches have been filled in, every street in the district having been excavated. Two strong concrete embankments have been built at the foot of the streets leading to the water. The contract will probably be let very shortly for the laying of the pipes in the Esquimalt village section. This section will cover the whole west end of the municipality not drained by the other sections.

PERSONAL.

D. H. MARTIN has been appointed chief engineer for Jas. Corbett and Sons, Limited, who have one of the subcontracts for Section 5 of the Welland Ship Canal.

FRANK C. ASKWITH is provisionally in charge of roads and bridges for the city of Ottawa, since the resignation of Mr. Arch. Currie. R. L. HAYCOCK has been placed provisionally in charge of the waterworks and sewerage department, succeeding Mr. A. N. Beer, resigned.

A.S.T.M. EXECUTIVE.

The officers of the American Society for Testing Materials for the year 1914-15 are:—President, A. W. Gibbs; vice-president, A. A. Stevenson; secretary-treasurer, Edgar Marburg; council, Robt. Job, F. W. Kelley, A. Marston and S. S. Voorhees.

CANADIAN FORESTRY CONVENTION POSTPONED.

Owing to the war the president and directors of the Canadian Forestry Association have, after the most careful consideration, decided to cancel the arrangements for the forestry convention which was to be held in Halifax, September 1st to 4th, 1914, and to postpone the convention indefinitely. Whatever it is decided to do in the future, due notice will be given thereof to the members and all others concerned. Attention is particularly directed to the fact that all railway arrangements as published have been cancelled, and that anyone going to Halifax within the stated dates will have to pay full fare back to starting point. All persons receiving notice are requested to make it known to any others who they know were preparing to go to Halifax.

OBITUARY.

The death is reported of Mr. H. W. Anthes, managing director and secretary-treasurer of the Anthes Foundry, Limited, of Toronto and Winnipeg. Mr. Anthes was in his sixty-fourth year.

HARDNESS OF WOODS.

Woods are going rapidly out of fashion in railroad car construction, when only a few brief years ago they formed the entire structure of cars.

The relative hardness of woods is calculated from hickory which is the toughest and hardest wood in popular use. Estimating hickory at 100, we get for white oak, 84; white ash, 77; dog wood, 74; scrub oak, 73; white hazel, 72; apple, 70; red oak, 69; white birch, 65; black walnut, 65; black birch, 62; yellow and black oak, 60; hard maple, 56; white elm, 58; cedar, 56; cherry, 55; yellow pine, 53; chestnut, 52; yellow poplar, 51.

COAL EXPORTS FROM GREAT BRITAIN.

The total amount of coal exported from Great Britain in 1913 exceeded that of 1912 by ten million tons. Cardiff topped the list as usual, according to a consular report. From the Manchester ship canal the export amounted to about 1,100,000 tons, but these figures are insignificant when the facilities for shipment are taken into account. The quay space at Partington coal basin occupies 20 acres and there are 22 miles of railway sidings. Six tips are in use fitted with hydraulic machinery and each tip has a capacity of 300 tons per hour. Manchester is the nearest point of shipment for the Lancashire, Derbyshire and Staffordshire collieries.

EFFECT OF SODIUM HYDROXIDE ON IRON.

In a paper by J. H. Andrew in the Transactions for March, 1914, of the Faraday Society, it is stated that wrought iron corrodes slowly, becomes highly crystalline, and eventually brittle by immersion in a concentrated aqueous solution of sodium hydroxide at 100° C. for several months. The corrosion is attributed to electrolytic action between the two phases, crystalline and amorphous, of which the metal is constituted, iron going into solution at the anode (forming sodium ferrite), hydrogen being liberated at the cathode. Part of the hydrogen is occluded by the metal, being first absorbed by the amorphous constituent, thereby forcing the crystals apart, and ultimately causing the iron to become crystalline and brittle. The brittleness decreases with time, an equilibrium being finally established between the metal and the gas, and is due rather to the molecular rearrangement induced by mere occlusion or evolution of hydrogen than to the mere presence of the latter in solution. The potential difference between the amorphous and crystalline phases and hence the rate of corrosion decrease as the latter phase becomes hydrogenized, the passivity of iron produced by immersion in caustic soda being due to this cause. Similar results were obtained with electro-deposited iron, but steel containing 0.5 per cent. carbon was much less affected by sodium hydroxide solution. The recrystallization of electro-deposited iron upon cooling through the Ar_3 point is also considered to be due to the evolution of hydrogen.

COMING MEETINGS.

CANADIAN FORESTRY ASSOCIATION.—Annual Convention to be held in Halifax, N.S., September 1st to 4th, 1914. Secretary, James Lawler, Journal Building, Ottawa.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Secretary, Will P. Blair, 832 B. of L.E. Building, Cleveland, Ohio. Eleventh annual convention and paving conference, Buffalo, N.Y., September 9th, 10th, 11th, 1914.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown, Indianapolis, Ind., Secretary.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.—11th Annual Convention; 5th American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau St., New York, N.Y.

ORDERS OF THE RAILWAY COMMISSIONERS OF CANADA

Each week on this page may be found summaries of orders passed by the Board of Railway Commissioners, to date. This will facilitate ready reference and easy filing. Copies of these orders may be secured from *The Canadian Engineer* for small fee.

22294—July 24—Amending Order No. 22160, dated July 8th, 1914, to provide that Henry Ray, Tp. March, Ont., deposit in a chartered bank to credit of Board of Ry. Commrs. for Canada, sum of $500 in lieu of and for purposes of bond required under Order 22160 to be filed with the Company.

22295—July 23—Authorizing C.P.R. to construct spur into premises of International Supply Co., Limited, on Lot F, Medicine Hat, Alberta.

22296—July 27—Directing that C.N.R. construct spur 1,900 ft. long to connect with spur serving Estevan Coal and Brick Co., subject to certain conditions, Ry. Co. to construct and complete spur as soon as Bienfait-Estevan Branch is open.

22297—July 29—Authorizing, until Nov. 30th, 1914, C.N.R. to open for traffic its North Battleford Northwesterly line from Edam, mileage 38, to Turtleford, mileage 57: Provided speed of trains be limited to rate not exceeding 15 miles an hour.

22298—July 31—Authorizing Esquimalt and Nanaimo Ry. to open for traffic, McBride Jct. to Courtenay, Vancouver Island, B.C.; and rescinding Order No. 27546, dated Oct. 13th, 1914.

22299—July 30—Dismissing application G.T.R. for authority to construct, at grade, spur track serving Elias Rogers Co., Coal Dealers, Toronto, Ont., across Toronto, Grey and Bruce Ry. (C.P.R.) at point south of St. Clair Ave., Toronto.

22300—July 28—Authorizing Toronto Eastern Ry. and Oshawa Electric Ry. to operate trains and cars, for period of 6 months from Aug. 6th, 1914, over crossing in Town of Oshawa, Ont., subject to provisions of Section 277 of Railway Act.

22301—July 29—Amending Order No. 22297, dated July 3rd, 1914, by striking out words "Swift Current," in 2nd line of paragraph 2 of operative part of Order, and substituting therefor words "Moose Jaw."

22302—July 27—Directing G.T.P. Ry. to carry out certain conditions for purpose of providing good and sufficient accommodation and facilities at Spruce Grove, Alberta.

22303—July 31—Directing that spur located between King St. and Pembina Bridge, Entwistle, Alta., be removed; that spur for 5 cars be installed east of King St., with trailing point switch toward King St.; G.T.P. Ry. to arrange to handle carload freight for Village of Entwistle and those who require it at that point.

22304—July 31—Authorizing Corporation City of Toronto to reconstruct bridge, partly in City of Toronto and partly in Twp. York, carrying highway over Belt Line of G.T.R.; cost of construction be paid—60 per cent. by Corporation of City of Toronto; 20 per cent. by Twp. York; and 20 per cent. by G.T.R.; cost of maintenance be borne by Corporation of City of Toronto.

General Order, No. 130—July 28—Disallowing schedules of Boston and Maine R.R., C.P.R., Central Vermont, G.T.R., G.T.P. Ry., G.N.R., Maine Central, M.C.R.R., Rutland R.R., N.Y.C. and H.R.R., T., H. and B. Ry., and Wabash Railroad, in so far as their purpose is to increase tolls previously charged for exclusive use of drawing-rooms or compartments in sleeping and parlor cars locally between points both of which are in Canada.

22305—July 31—Authorizing Winnipeg, Selkirk and Lake Winnipeg Ry. to construct and operate its Middlechurch Branch running to Stonewall, across spur of C.P.R. running to stone quarry at Stony Mountain, Man.; if at any future time protection is required at crossing, Applicant company provide same at its own expense.

22306—July 29—Authorizing G.T.P. Saskatchewan Ry. to operate over crossings of C.P.R. Weyburn-Lethbridge and Soo Branches, by its Weyburn Branch, in Sec. 20-8-14, W. 2 M., at Weyburn, Sask, until Oct. 15th, 1914, pending installation of interlocking plant: Provided crossings be protected by flagmen appointed by C.P.R., at expense of G.T.P. Sask. Ry.

22307—July 27—Directing that, within 60 days from date of this Order C.L.O. and W. Ry. install improved type of automatic bell at crossing of Frontenac Road, in Village of Parham, mileage 26.97.

22308—July 29—Authorizing, subject to terms of Indenture of Lease, M.C.R.R. to construct spur for Union Carbide Co. of Canada, Limited, crossing Bain Ave. and Welland Canal Tow Path, Twp. of Crowland, Co. Welland, Ontario.

22309—July 29—Authorizing Alta. Central Ry. to open for traffic its line West of Red Deer, mileage 0.00 to 64.5.

22310—July 31—Authorizing Union Bank of Canada, Moose Jaw Branch, to release and repay to S. A. Hamilton Co., Limited, sum of $1,100 deposited with it to credit of Board, together with accrued bank interest, if any.

22311—July 29—Authorizing Board of Highway Commissioners for Saskatchewan, at own expense, to construct highway over G.T.P. Branch Lines Co.'s Regina Boundary Branch, on Extension of Queen St., Townsite of Colfax, Sask.

22312—July 31—Authorizing G.T.P. Ry. to construct an extension to bridge over Fraser River, mileage 468.4 Prince Rupert East, B.C.

22313—July 30—Authorizing C.N.R. to construct revised line across C.P.R. in S.W. ¼ Sec. 19-40-26, W. 4 M., near Lacombe, Alta., subject to certain conditions.

22314—July 29—Authorizing C.N.R. to operate its trains, temporarily, for construction purposes only, for period of 60 days from date of this Order, pending installation of interlocking plant, over crossing of C.P.R. in Lot 101, Parish of St. Paul, Man.: Provided trains be flagged over crossing by watchmen appointed by C.P.R. at expense of C.N.R.

22315—August 4—Extending the area for the collection and delivery of express freight by Express Companies in the city of Windsor, Ontario, and rescinding Order No. 19533, dated June 9th, 1913.

22316—August 1—Directing that G.T.P. Ry. construct a station, not to be below Standard of No. 1 B.R.C., and a one-pen stock yard at Ribstone, Alta.; work be completed by September 15th, 1914. Ry. Co. stop trains Nos. 1 and 2 on flag signal, at Ribstone, for passengers and express.

22317—July 24—Directing that G.T.R. construct spur into premises of Standard Crushed Stone Co., Limited, near Windmill Point Station, Ontario, subject to certain conditions.

22318—August 1—Extending, until October 31st, 1914, time within which G.T.R. complete subway at Thompson Road, Tp. Bertie, Ont.

22319—July 30—Authorizing C.L.O. & W. Ry. (C.P.R.) to operate its trains across C.N.O.R. in Lot 27, Con. 2, Tp Pickering, until Sept. 15th, 1914, temporarily, pending installation of interlocking plant: Provided crossing be protected by flagmen appointed by C.N.O.R. at expense of C.L.O. & W. Ry.

22320—August 1—Authorizing C.P.R. to construct road diversion in Sec. 34, Tp. 5, and Sec. 3-6-24, W. 3 M.; and construct, by means of grade crossing, its Weyburn-Stirling Branch Line across East and West road allowance between Sec. 34, Tp. 5, and Sec. 3-6-24, W. 3 M., Sask., at mileage 272.7 of said Branch Line.

22321—August 1—Authorizing C.P.R. to construct its Weyburn-Stirling Branch Line across twelve (12) highways, between mileage 65 and mileage 75 (mileage 0 being at Stirling).

Volume 27. Toronto, August 20, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

BURRARD INLET BRIDGE, VANCOUVER

SOME IMPORTANT DETAILS OF THE PROPOSED DESIGN—TO BE THE LONGEST SWING SPAN IN EXISTENCE—UNFORTUNATE DELAYS IN AWARDING CONTRACT.

THE Corporation of North Vancouver has long been in need of closer connection with the City of Vancouver, from which it is separated by Burrard Inlet. The desired thoroughfare would afford access not only to the railway, but to the business and commercial district of the city. It has only been of recent date, however, that any activity has been commenced. Large increases of traffic, together with the advent into North Vancouver of a branch of the Grand Trunk Pacific, known as the Pacific Great Eastern Railway, has emphasized the importance to both communities of a direct connection. In addition to the access which the proposed bridge will give the Pacific Great Eastern Railway into Vancouver from the North, an electric interurban car line, together with ample driven and pedestrian traffic, is being afforded accommodation in the design under contemplation.

The location that has been chosen is over a section of the Inlet known as the Second Narrows, three miles in distance from the First Narrows, or entrance to the Inlet.

The design itself is for a complete structure to span the Inlet. The approach at the Vancouver side requires considerable embankment and cutting, while on the north side there will be quite a length of trestle work and embankment, chiefly on the railway right-of-way.

The Official Design.—An important feature of the contemplated structure lies in the dimensions of the swing span. The official design was prepared by the English firm of Sir John Wolfe Barry, Lyster and Partners, with whom is associated in Vancouver the firm of Cleveland and Cameron, as consulting engineers to the Board of Directors of the Burrard Inlet Tunnel and Bridge Company.

According to the official design, the length of the swing span will be 581½ ft. between centres of the end bearings. This length exceeds the longest present swing span by 62 ft. In width the structure will be 59½ ft., providing, as stated, for railway, highway, street car and pedestrian traffic accommodation. There will also be two fixed spans 232 ft. in length from centre to centre of bearings. These three Warren type spans; i.e., the single swing and the two fixed spans, approximately cross the entire width of the river at low water, its width at this stage being 1,030 ft. at the proposed site of the bridge. In flood stage, however, it has attained a width of 3,248 ft., the additional flooding occurring for the most part over the north bank of the Inlet. The bridge approach over this low ground consists of a plate girder viaduct, with tower spans of 29 ft. and intermediate spans of 43 ft. 6 in. The highway portion of the approach is 25 ft. 10 in. in width and is carried on vertical posts. The railway portion will rest on posts battered 1:4½. All trestles and posts will be supported by concrete foundations.

The approach to the bridge on the Vancouver side crosses the tracks of the Canadian Pacific Railway by means of two skew bridges, side by side, one to carry the steam traffic of the Pacific Great Eastern Railway and the other the roadway and electric car tracks. The

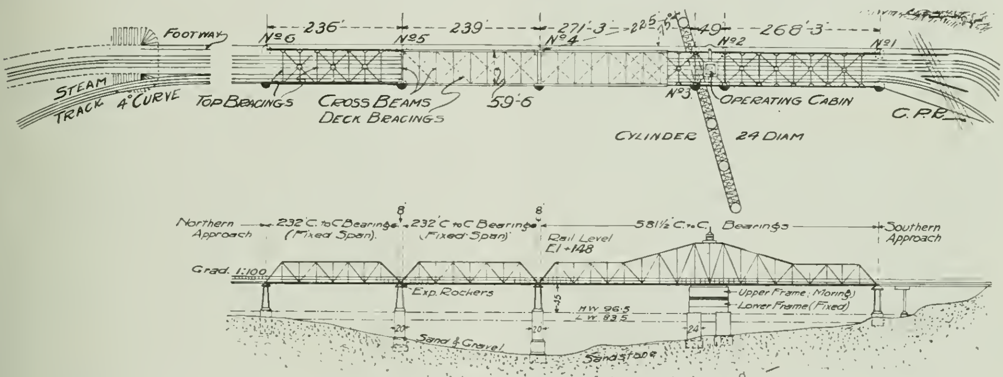


Fig. 1.—Sketch of Plans for the Second Narrows Bridge, Prepared by Sir John Wolfe-Barry, Lyster & Company, England.

railway portion of this span is to be 168 ft. in length and the highway portion will be approximately 108 ft. long. This makes up a total length of 3,449 ft. for the railway section of the bridge and 2,364 ft. for the highway section. The skew bridges are connected with the south end bearing of the swing span of the main bridge by short plate girder spans. They give a clearance of 22½ ft. over the top of rail of the Canadian Pacific Railway line.

The bridge proper will carry between trusses a single railway track on the west side, and a 37½-ft. roadway between curves, including two electric car tracks on its east side. There will be an 8-ft. cantilevered footway outside of the eastern truss for the entire length of the bridge.

The foundation work will be expensive and rather difficult owing to the great depth of water and to somewhat unsatisfactory conditions of the river bed. The depth in the channel is 96½ ft. at ordinary tide stage, with a tide range of 13 ft. The north bank consists of gravel to a depth of 155 ft., overlain with about 5 ft. of silt. The south shore is composed of sandstone rock with a considerable overlay of soft mud. In mid-channel the two strata meet in a bed of gravel and boulders. In addition to the above the tide currents through the Second Narrows have a velocity of approximately 7 knots. Diving operations are rendered difficult owing to the continuation of the bottom flow for a considerable length of time after the turn of the tide.

According to the official design, there will be a clearance of 45 ft. above ordinary spring flood stages. The line of the swing span will afford a minimum depth at low water of 35 ft. under its north arm. At the swing span a clear waterway of 225 ft., measured square to the channel, is provided, as requisitioned by the Department of Railways and Canals of the Dominion government. There is a skew of 15° in the line of the bridge across the channel.

The span is to be supported by four wrought steel cylinders, filled with concrete and resting on piles. They are to be spaced 49 ft., centre to centre, both ways, and braced. The south end bearing will rest on a pair of wrought steel braced columns resting on cylinder piers 59½ ft. apart. The north end bearing will be supported by similar columns on a solid pier, full bridge width. The fender pier, in the plane of the swing span, when open will consist of six cylinder piers 24 ft. in diameter, with bracing and timber fender work between.

The operation of the span, the locking of the bridge, the opening and closing of the gates, as well as the signalling apparatus for river and land traffic, will be electrically controlled. The operating cabin is located above and at the centre of the span.

Delays in Proceeding.—The above plans, prepared by the English firm, provide a design estimated to cost $2,500,000. The Burrard Inlet Tunnel and Bridge Co., finding difficulty in the financing of such a large undertaking, appealed to the Provincial Government to take over the entire project. The latter declined, however, and announced that it was not prepared at that time to subsidize the enterprise to a greater extent than $400,000, previously arranged, and advised the company to build a less expensive structure.

Subsequently, Mr. C. P. Moss, local representative for the Strauss Bascule Bridge Co., submitted plans for a bridge of the Bascule type to the government, which, in turn, recommended them to the company as they involved a cost of approximately $1,500,000. This design had spans of 44 ft., centre to centre of trusses, and provided for two electric railway tracks in addition to the steam railway line, and a 16-ft. roadway. Outside of the truss line an 8-ft. sidewalk was provided on brackets for pedestrian traffic. The required width of 225 ft. in the channel, overhead clearance of 45 ft. between water at high level and under side of the spans over the navigable channel, and a clearance of 22½ ft. over the rails of the Canadian Pacific Railway were all provided for. The design suggested a movable span of the Heel trunnion type, with concrete counterweights. Electrical operation by two 90 h.p. motors, in addition to a 5 h.p. motor to operate locking mechanism, was called for. The time of opening or closing under normal conditions was stated to be 1½ minutes.

Acting upon the advice of the Provincial Government the company called for tenders for a cheaper structure, and a number of plans and specifications were submitted accordingly. Chief of these were the tenders of the Dominion Bridge Co., associated with Armstrong, Morrison & Co.; the Canadian Bridge Co.; and C. A. P. Turner, associated with the Western Foundation Co. These three designs were submitted to Messrs. Cleveland & Cameron, the consulting engineers to the company, for a report. The following is a summary of their findings and conclusions, many points of interest arising therein:—

Tender No. 1.—The design submitted follows the official design as to general outline.

The length of the plate girder spans for the north approach are slightly increased.

The two fixed truss spans are the same length and occupy the same positions.

The clear opening provided by the swing span is the same, but the length between end bearings has been reduced from 581 ft. 6 ins. to 578 ft. 0 ins.

Truss spans have been used for the south approach over the tracks of the Canadian Pacific Railway.

The substructure designs for the north approach substitute pedestals on pile foundations for the cylinder piers of the official design.

The pedestals are carried down to 10 ft. below the ground line for the first three bents, 8 ft. for the following three, and 6 ft. for the remaining bents; they are all carried on piles having a maximum load of about 16 tons per pile, which is good, conservative practice.

The design of the pivot pier differs from that of the official design in consisting of a single 56-ft. diameter cylinder in place of four 24-ft. diameter cylinders, spread at the base to 28 ft. The bearing pressure is about 6 tons per square foot.

The north rest pier, on Pier No. 4, consists of two shafts in place of the solid pier called for in the official design. Sufficient bearing area is provided, but the pier is not so well able to withstand the blow from a heavy vessel. With this exception, we consider the design for the substructure an excellent one.

Wooden caissons are used in place of steel for all piers, and the piers are carried to the maximum height and the steel bents under trusses eliminated.

The superstructure has been designed for the Dominion Government especial heavy loading on the steam railway track, two 40-ton electric cars on each tramway track, and the balance of the floor has been figured for 100 pounds per square foot for the floor system and 60 pounds per square foot for the trusses.

The floor system has not been designed for a concentrated load similar to the heavy motor trucks which it will have to carry.

A unit stress of 18,000 pounds per square inch has been used in the design of the west or railway side truss, and 20,000 pounds per square inch for the east truss. We are of the opinion that since this structure carries railway traffic as well as electric railway these stresses

are too high. The Dominion specifications allow 16,000 pounds per square inch for railway bridges.

The centre chord members of both trusses of the swing span, which receive their maximum stresses while the bridge is swinging, are designed for a unit stress of 20,000 pounds per square inch, due allowance being made for impact as per Clause 186 of the Dominion Government specifications.

The centre girders of the draw are designed for 18,000 pounds per square inch.

The arrangement of the centre and radial girders of the swing span is such as to load the drum at thirty-two points, but these points are not uniformly spaced, thirty of the spaces being about 4 ft. 3 ins., and two of them 15 ft. 0 ins., centre to centre. This gives uneven distribution of the load to the rollers. A portion of the load is carried to the centre pivot and the rollers and the lower track are securely tied to the pivot as required by good practice in draw-bridge designs.

In other particulars the bridge follows the lines of good practice in bridge design.

Tender No. 2.—The design submitted is similar to that of Tender No. 1, except that the swing span is the same length as on the official plans, but the pier design

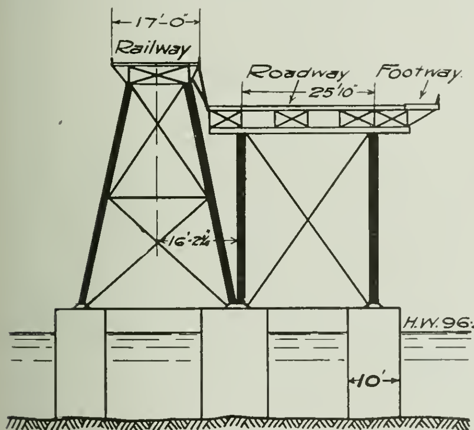


Fig. 2.—Typical Cross-Section of North Approach.

is such as to allow of this length being decreased, still maintaining the same clear opening.

Through plate girders are used in place of trusses for the highway approach over the Canadian Pacific Railway tracks.

The substructure has been designed for Dominion Government heavy loading on the railway track and two 40-ton electric cars on the tramway tracks, the balance of the floor has been figured for 100 pounds per square foot, or a 20-ton traction engine for the floor system, and 60 pounds per square foot for the trusses.

The 20-ton traction engine is practically equivalent to a modern heavy motor truck.

In proportion, the floor beams and truss members, the stresses due to dead load and railway loading have been provided for a unit stress of 16,000 pounds per square inch, tramway loading at 18,000 pounds per square inch, and highway loading at 20,000 pounds per square inch.

The centre chord members of the swing span which receive their maximum stress while the bridge is swinging are designed for a unit stress of 16,000 pounds per square inch. This unit stress has also been used in the design of the centre girders. Due allowance has been made for impact in all cases.

The drum is 42 feet diameter, which is smaller than used on other designs submitted, but the arrangement of the centre and radial girders is such that the rollers are evenly loaded and not overstressed. In this design, as in the design of Tender No. 1, a portion of the load is carried to the centre pivot, which is a desirable condition.

Two 200 horse-power motors are to be supplied for swinging the bridge. This is sufficient for rapid operation, with ample power in case one motor is under repair.

The design follows the lines of accepted good practice in modern bridge construction.

Tender No. 3.—The design follows the lines of accepted good practice in design for the channel crossing from low water to low water. It consists of one 60-ft. and one 80-ft. plate girder span, one 345-ft. truss span and the 586-ft. swing span.

The substitution of the three fixed spans for two, as on the official design, would necessitate a change in the Crown grant already obtained of portions of the bed of the Narrows.

The clearance above high water is not as great under the plate girder spans as for the same location on the official design.

The south approach consists of plate girder spans up to and over the tracks of the Canadian Pacific Railway.

The length of bridge shown on the plans for the south railway approach is about thirty feet short.

The north railway approach consists of a series of deck plate girder spans on reinforced concrete towers without longitudinal bracing. This portion of the approach is 39 ft. shorter, and the top of rail at abutment is 2 ft. 3 ins. higher than called for on the official plan.

Two designs have been submitted for the north highway approach. One of these consists of the mushroom system, or flat slab construction; the other consists of plate girder spans on concrete columns.

The alternative design submitted for the north highway approach consists of a flat, reinforced concrete, continuous slab on reinforced concrete columns on a pile foundation.

We do not consider that this is a good type of construction for this location. The strength of the structure depends upon a total absence of settlement of the supports, which it is practically impossible to get in this location with the details shown. Some of the supporting piles have a load of about 45 tons, or about 20 tons per pile overload.

The length of spans of the mushroom approach and the adjoining railway approach being different, the two lines of piers, about 9 ft. apart, obstruct about 33 per cent. of the waterway.

The plate girder spans of the north railway approach follow the lines of usual practice, but the end stiffener angles of the 60-ft. spans are too light to properly transfer the end shear from the webs to the angles and bearing plates.

No lateral bracing is shown or called for on the drawings, between the bottom flanges of the 60-ft. and 80-ft. deck plate girder spans; these are required by the Dominion specifications.

No longitudinal bracing is provided between the towers to take care of the forces due to traction or suddenly stopping a train. In the drawing presented these forces cause bending in the columns and the pedestals supporting the tower, which gives tension on the one side and excessive load on the piles under the opposite side of the pedestal. These piles, without the load due

to this lateral force, are loaded with over 35 tons each.

Piers No. 0 and No. 1 are not carried as deep as the similar piers of the other two designs, resulting in a large difference in value between the different structures.

Pier No. 2 (north rest pier) consists of two shafts joined by braced side webs. The bid suggests filling the space between these webs with a lean concrete at an extra cost of $7,000. This would enable the pier to withstand a heavier blow from a colliding vessel.

The pivot pier consists of a reinforced concrete cap supported by four cylinders, each 22 ft. in diameter. The bearing area is considerably less than provided by the other designs and the pressure on the foundation much greater.

Reinforced concrete shells of 1:1 1-2:3 concrete are used for piers 1 to 3 inclusive, but for all massive work, with the exception of Pier No. 5, a leaner concrete is used composed of 1:3:5 with the addition of two parts of coarser aggregate.

The superstructure has been designed for Dominion Government heavy loading on the railway track, 40-ton electric cars on the tramway, and 60 pounds per square foot on the balance of the roadway and the sidewalk.

The floor system has been designed for traction engine or motor truck similar to that assumed in Tender No. 2.

The fixed span is of the Warren type, and is 340 ft. to centre of bearings. The maximum unit stress in the bottom chord is 18,000 pounds per square inch for the west or railway truss, and 20,000 pounds per square inch for the east or highway truss. Full allowance has not been made for impact in the centre diagonals as required by the Dominion specifications, and as allowed by the other competitors. With this allowance added, unit stresses of 24,000 pounds per square inch exist in the railway truss.

Short redundant members are used to reduce the unsupported length of the vertical posts and hangers. This is not good practice, as they introduce secondary stresses in the members.

Sway frames between the trusses are not provided at all panel points as required by the Dominion specifications.

In the design submitted the swing span has sufficient lift of the ends to make the trusses non-continuous, so that they form two separate simple spans when the bridge is closed. This is a desirable arrangement if the boat traffic is so light as to require but few openings and the bridge is used almost entirely as a fixed span.

The heaviest structure of this type which has been built is the Charlestown bridge at Boston, the weight of which is about one-third that of the span under consideration. When swinging to its closed position the ends are lifted by hydraulic jacks, requiring about eight times as much work as when the ends are only lifted enough to prevent all tendency to hammer under the rolling load. The time required for operation is also greater.

To lift the ends by the centre top chord bars as is done in the design under consideration is not economical, as it requires about four and a half times the power that is required to do the lifting at the ends. The designer may claim that the toggle arrangement reduces this, but a toggle or similar arrangement can be used in either case. It is the ends that have to be lifted; and the more direct the application of power, the less is required.

A noted authority on swing bridges in a paper presented at a meeting of the American Society of Civil Engineers on April 3rd, 1907, says: "A few bridges have been built with a lifting apparatus applied at the top chord of the centre panel. This arrangement has the additional disadvantage of using a part of the structure which carries the strain while the bridge is swinging, also as a part of the lifting mechanism, which is not good practice. If the machinery parts get out of order the structure should not be affected thereby. The writer's experience with a bridge of this kind prompts him to advise its use."

In the swing as in the fixed span redundant members have been inserted between the diagonals, and sway frames omitted at four panel points where required by the Dominion specifications and good practice.

Full allowance has not been made for impact in the diagonals, and the stresses in the diagonals and chords are high.

The centre chord eyebars are stressed by direct stress and impact to 21,000 pounds per square inch. Tender No. 1 has 20,000, and Tender No. 2 16,000 pounds per square inch for the same members under the same conditions. In this design the centre eyebars have to resist the bending due to the friction at the pins or trunnions when raising or lowering the ends of the span. As the pressure between the bushing and pin is about 8,000 pounds per square inch, the friction should not be assumed as less than 20 per cent., which gives a unit stress from bending of 7,500 pounds. This, added to the direct stress and the proper allowance made for impact gives a total stress of more than 31,000 pounds per square inch, or about the elastic limit of the material.

The pressure between the nickel steel bushing and the trunnions at the centre is over 8,000 pounds per square inch. This bearing has to perform a similar service to the trunnions of a bascule bridge, although the movement is not so great. The specifications of Sir William Arrol and others allow a pressure of 2,500 pounds per square inch, and Unwin allows a pressure of 3,000 pounds per square inch on such bearings.

The centre lifting screw has a pressure of about 1,470 pounds per square inch on the thread. The specifications of B. R. Leffler, engineer of bridges of one of the large American railway companies, published in the transactions of the American Society of Civil Engineers, allow a pressure of 200 pounds per square inch on screws which transmit motion.

In this design the total weight of the bridge while swinging is carried by the drum, which is connected to a light centre casting by radial struts. We are of the opinion that this cast-iron centre has not sufficient strength to centre the bridge when closing or to prevent its being knocked out of position. It is an advantage to carry a portion of the total weight on the centre pivot, as is done in the other designs, for it assists in resisting any tendency toward lateral movement on the part of the live ring.

The drum is loaded at sixteen points, but these points are not evenly distributed, some of the spaces being about 7 feet, while others are about 26 feet. This is most unsatisfactory arrangement, as unequal distribution, on account of the deflection of the drum between points of loading, gives unequal load on the rollers; this, besides giving excessive pressure, distorts the live ring and causes the bridge to turn hard, with unnecessary wear and tear on the rollers, track and spider.

If the load is evenly distributed the pressure on the rollers would be about 14 per cent. greater than allowed by the Dominion specifications. With the uneven distribution the load would probably be about 40 per cent. greater.

The centre pivot in this design is entirely independent of the lower track and rack. They should be con-

nected by radial struts so that they can be erected and centred accurately in the shop, and when later put in position will occupy the same relative position.

In this design the live ring is connected to the centre pivot by radial rods, which are connected on the outside of the wheels by a flexible ring and on the inside by an angle. With this construction the centre ring around the pivot does not start to turn as soon as the wheels, but drags, and the rods through the rollers are thrown out of radial lines, so that the rollers do not run concentric with the top and bottom treads.

This is the reason for a large percentage of the broken wheels of old swing spans, and it also increases the power required for turning.

With reference to the drum wheels and spider, Tenderer No. 3 states: "It approaches very nearly that of the great swing span over the Thames River at New London, Conn., which it follows very closely in general design." This bridge was built more than twenty-four years ago, and, although the span is nearly 500 feet, the construction is light.

The specifications of Sir William Arrol say: "All radial bars and the roller frame of the live ring shall be formed of rigid members with suitable tangential bars to maintain the relative motion of the parts of the frame."

One of the Past Presidents of the American Society of Civil Engineers, in a paper on "Movable Bridges," presented before the Society on April 3rd, 1907, describing this type of construction, says: "The live ring arrangement for separating and holding the rollers which was formerly popular, consisting of adjustable radial rods, one end of each rod carrying a roller, the other end being connected to a ring devolving round the centre pivot, is, to say the least, an unmechanical contrivance. Good practice requires a more substantial construction. The rollers should run between two concentric circular girders firmly connected to each other; this ring should be connected to the revolving part of the pivot by rigid struts."

The design of the end shoes does not meet the requirements of good, modern practice, which requires supports for the ends of a swing span of solid, substantial construction similar to the end shoes of a fixed span. In this design the bearing pressure of the roller on the cast steel base is excessive and the base is too shallow to distribute the reaction over its full area.

It is stated that the ⅞-inch cup at the centre of the casting is for lock and centring device when closing. Tenderer No. 3 says: "These shoes are likewise of simple but massive construction. Cast steel bearing plates having an inclined approach and a hollow provided for the seat of the 16-inch solid steel roller bearing supporting the draw-arm. These rollers are to have a 9-inch pin and bearing at each end. This roller bearing is designed to form an automatic locking device and centreing device in addition to the rail lock for the bridge when it is closed, the roller, by gravity, rolling into the cup or seat provided."

In order to have the roller and the base casting centre the bridge when closing, the ends of the span must be lowered by lowering the ends of the centre eyebars through a percentage of their travel before the span has been turned to its final position. If the lowering has been excessive the momentum of the span will not be sufficient to carry the ends up the inclined path on the base casting, while if the ends have not been sufficiently lowered the momentum will carry the span past the ⅞-inch drop provided for the centreing. The momentum of the span must be sufficient to lift the ends up an inclined plane until a point 8 inches from the centre is reached and to carry the span on a horizontal plane for a distance of about 4 inches, but it must not be so much as to carry the ends 4 inches past the centre, or the device fails to act. As the deflections of the two trusses are different and vary with the temperature, the chances of successful operation are very small.

Suddenly dropping the ends of the bridge ⅞ of an inch will produce a hammer action on the cast steel base and a racking strain all through the structure.

Summarizing, we would say that the pressure on the foundation for the pivot pier is much higher in the 3rd design than in the other designs submitted.

The piles for the north approach foundations are loaded more than twice as high in the 3rd as in the other designs.

Maximum unit stress in the chord members of the trusses are 32 per cent. higher in the 3rd and 25 per cent. higher in the 1st design than in the 2nd.

The 1st and 2nd designs follow the lines of accepted good practice in modern swing bridge construction. The 3rd design is a distinct departure, and the largest structure operated in a similar manner, of which we can find any record is a double-track swing bridge, 228 ft. long, at Hammond, Indiana. In this structure the ends of the bridge are raised by means of double toggles in place of the single toggles.

The recommendation of the consulting engineers, however, was at variance with that of the British Columbia Manufacturers' Association, the Board of Trade, and other public organizations.

Despite the fact that the Provincial Government is exceedingly desirous that the company proceed without delay in the construction of the bridge in order to have the structure completed by the time the Pacific Great Eastern Railway connects North Vancouver with Fort George, little progress can be announced. The directors of the company appealed to the Government in the matter of awarding a tender. The Government, however, expressed itself as indisposed to take the responsibility of making an award and referred the question back to the Board of Directors. Numerous alterations to tenders were permitted, all three undergoing various changes. Then the Board decided to place the whole question before a disinterested engineer, fully capable of recommending the best award. Mr. Ralph Modjeski, of Chicago, was accordingly retained on July 10th, 1914. His report is expected in a few weeks, whereupon an award will probably be made.

INTERNATIONAL IRRIGATION CONGRESS.

There will be no postponement of the session of the International Irrigation Congress, which is scheduled for October 5th to 9th. On account of the war and the fact that European countries would not be in a position to participate in the Congress, some question arose as to the advisability of holding a session this year. It has, however, been decided to go ahead as previously planned confining the work to the United States and Canada. The Dominion and provincial governments which are really most interested in the success of the gathering, have concluded that it will be better to proceed than to postpone.

In the fear that the United States government may make the coal product contraband of war, all the Rochester and Pittsburg coal company mines in Indiana county have received word to start all mines full time, give all miners employment, and get out all the coal possible. The Canadian railroads have placed big orders and want the coal shipped to Canada at once.

REINFORCED CONCRETE DOCK CONSTRUCTION.

THE study of reinforced concrete docks involves so many phases of the problem that they are difficult to cover with any degree of completeness in a single article. There are many in successful operation in Europe, the most extensive development being in England, where they have, to a certain extent, proven their practicability and commercial economy. But in America they are more or less of a novelty, and can hardly be said to have, as yet, proven themselves. For this reason there is much of interest in a review of the art of reinforced concrete dock construction given by Harrison S. Taft in a paper on May 20, 1914, before the American Society of Civil Engineers—particularly in that portion of the paper outlining the practice in the old world and examining the work in each country. Their successful use for about 50 years in Europe for structures exposed to the action of salt water leads one to the conclusion that what has been done there, and in other parts of the world, will bear investigation. We extract the following pertaining exclusively to English practice, from Mr. Taft's paper:

In building reinforced concrete docks and other concrete structures in sea or fresh water, it is only natural that a forested country should be the last to take up the development of such a material. Consequently, America has been far in the rear in regard to this question, as compared with what other and older countries have accomplished. In England, France, Germany, Italy, and other European countries, in Australia, and in Asia, as well as in certain South American countries, concrete seawalls, breakwaters, dry docks, piers, trestles, coaling stations, etc., in salt water, have been in existence for years.

Southampton, Eng.—One of the most noted developments in reinforced concrete construction, as applied to harbor and dock development, is that of the London and Southwestern Railway Terminals at Southampton. The first and most prominent reinforced concrete structure in connection with this terminal was a coal barge jetty, 300 ft. long and 20 ft. wide, built in 1904, on the Hennebique system of driven concrete piles. The piles are about 44 ft. long, standing in 29 ft. of water at high tide, the rise and fall of the tide being about 13 ft. Each pile carries a maximum load of 17 tons.

This structure carries a very heavy traveling coal-hoisting apparatus for unloading coal from large vessels docked on one side, into harbor barges or scows which lie on the other side. Thus the jetty is subjected to constant blows from both sides, in addition to the heavy vibration due to the traveling machinery it supports.

In speaking of this jetty, Mr. Francis Wentworth-Shields, Dock Engineer for the London and Southwestern Railroad, says:

"Though the impacts from the vessels and scows cause this whole jetty to sway, there seem to have been no signs at the end of the first 2½ years of its existence of any of the concrete peeling off."

During recent years this dock or jetty is said to have shown some signs of deterioration, due to the vibration of the heavy machinery traveling along it, the supposition being that it was built too light in the first place to absorb the heavy vibrations to which it has been subjected. Still, the dock is said to have considerable elasticity. In one instance it was in heavy collision with a steamer, two piles and the beams they carried being broken. The dock was effectively repaired, but perhaps with some difficulty, though it is claimed that the repairs were easily accomplished.

The same railroad company has built several other reinforced concrete pile docks at Southampton, designed to carry the same heavy deck loads as the coaling jetty, but without the heavy vibration to which this jetty is subjected. Though built on the same system of construction as the coal jetty, the latter docks have shown no signs of wear or deterioration. It is said, on the best of authority, that they have cost nothing to date for maintenance.

The largest of these is the extension, on the Itchen Front, of "The Empress Dock," a widening of the so-called "Old Extension Quay" by a reinforced concrete pile structure, 50 ft. wide and about 1,300 ft. long, parallel to and securely dovetailed into the old quay wall. This widening dock is built of complete concrete bents, along the tops of which are steel deck-beams or stringers, which in turn are covered with 4 in. of wood, a wooden block pavement being used for the wearing surface. The depth of water at low tide at the face of this structure is 35 ft., which, with a 13-ft. rise and fall of the tide, gives a depth of 48 ft. at high tide.

One of the finest cold storage and cattle stations in existence was built at Southampton in 1905 to accommodate the foreign cattle trade. The landing stage or jetty of this station is a reinforced concrete structure, 200 ft. long and 38 ft. wide, connected with the main land by two runways, 142 ft. long and 15 ft. wide.

On the opposite side of Southampton Harbor, at Woolston, on the Itchen, there is a reinforced concrete landing dock, 136 ft. long and 100 ft. wide, built in 1899 on the Hennebique system. This was the pioneer of reinforced concrete dock construction in Southampton waters. Up to date, this dock has cost practically nothing for repairs, except for damages due to the fact that it was rammed or otherwise damaged by a large steamer; it is in excellent condition at present. The cost of making the repairs is said to have been very small.

Up to the present time, it appears that at least six reinforced concrete docks, jetties, or quays, have been built in Southampton waters.

In building one of the Southampton docks, it is stated that some of the concrete piles were sprung out of line in drying them. A prominent American engineer reports that he saw a number of piles from 1 to 2 ft. out of line, but that they showed no signs of cracks. It has been stated that, in handling Chenoweth concrete piles, up to a length of 61 ft., and 13 in. in diameter, they were rolled about like wooden piles, at times having quite a spring in them. Under this treatment they showed a remarkable degree of elasticity and no signs of cracking.

Bending of Piles.—In discussing the bending of concrete piles, it is of interest to note a series of tests made on a hollow telephone pole in Fulham, London, England, in 1911. The pole was 44½ ft. long, 17 by 17 in. at its base (outside dimensions), tapering to 8 by 8 in. at its head. The thickness of the shell was 2 in., making the inside dimensions of the pole 13 by 13 in. at the base and 4 by 4 in. at the top. The vertical reinforcement consisted of 248 3/16-in. rods of high-tension steel, the ultimate tensional stress being from 80,000 to 85,000 lb.; 56 rods were grouped at each corner, 6 rods being spaced evenly on each of the four sides of the pole. The area of the concrete at the base was 106 sq. in., and the area of the steel 6.85 sq. in., a ratio of 0.0445. In making the test, the pole was set in 5½ ft. of massed concrete, with the pulling rope attached to its upper end.

In Table I. is recorded the pull, in pounds, the deflection, and the permanent set after the loads had been released.

After applying the 6,000 lb., the test was discontinued for 3 days, and then the load was slowly increased to 9,200 lb., which gave a deflection of 66 in. and a permanent set of 21 in., with "cracks on tension side and permanent cracks more numerous and pronounced." There was no sign of failure on the compression side of the pole.

Table I.—Test of a Hollow Concrete Pole at Fulham, England.

Loads, in pounds.	Deflection, in inches.	Permanent set, in inches.
300	¾	None that could be observed
500	2	
1,000	4¼	
1,250	5	
1,500	6¼	
1,750	8	
2,000	9	
2,250	10½	
2,500	12	¼
2,750	14	½
3,000	14¾	⅝
3,550	19½	¾
3,100	16½	½
3,500	18¾	⅝
4,000	22	¾
4,500	25½	1⅛
5,000	29	1¾
Load gradually increased to 5,750	34	Pulling wire broke. Pole flew back, vibrated short time and came to rest in vertical position with no permanent set.
Load gradually worked up to 6,000	37½	2 in. immediately after release of load. After interval of 1½ hours, set was reduced to 11/16 in.

Add to the above loads 100 lb. for weight of wire and recording apparatus, etc.

Notes on Behavior of Pile.—At 3,350 lb., slight hair cracks appeared on tension side at about 5 ft. 6 in. above foundation.

At 3,600 lb., slight hair cracks appeared at regular intervals about 6 to 9 in. apart.

At 4,100 lb., slight shear cracks appeared, starting at 33 in. above foundation and extending vertically, at a distance of 2 in. from tension side, for some 3½ ft. in length.

At 4,600 lb., hair cracks occurred regularly, 3 or 4 in. apart on tension side.

At 5,100 lb., cracks on tension side were noticed to be traveling across the sides of the pole to within 6 in. of compression surface.

At 6,100 lb., the shear cracks were more pronounced. The hair cracks on tension side were about 1 in. apart, but no signs of failure appeared on compression side.

The load was again applied. When a deflection of 73 in. was obtained, signs of failure appeared for the first time on the compression side, and the pole failed, but no record of the amount of the pull was obtained. The final examination showed that the pile failed equally for its entire length on the shear and tension sides, but without any local weakness. The compression side failed from the base up for a distance of about 2 ft. The bending moment at the base of the pile was reported to be 4,863,936 in.-lb., a most remarkable test, which seems to substantiate the experience quoted above.

Liverpool.—The Mersey Docks and Harbor Board appears to have made a very limited use of reinforced concrete in its latest port developments, in spite of the extensive tidal and graving docks of concrete constructed at Liverpool. As a matter of fact, most of its first so-called reinforced concrete docks were in reality semi-concrete structures, that is, wooden piles carrying a concrete deck system. The oldest of these structures, the Cattle Wharf, Prince's Stage, was built in 1899-1901 on greenheart piles, with the usual Hennebique system of concrete deck-beams and slab. In addition to the Cattle Wharf, there are two other dock-quays in Liverpool, built on the same system, designed for a load of 3 tons per sq. yd., with a test load of 4½ tons.

Another of Liverpool's reinforced concrete docks is the Prince's Dock, West Quay, completed in 1905. This structure was designed to carry a super-load of 3 tons per sq. yd., or about 66 tons per pile. The piles are of concrete, 16 in. square, spaced 15 ft. 9 in. from centre to centre, across the dock, and 12 ft. 6 in. from centre to centre, longitudinally, and resting on rock.

At the west end of Liverpool's dock system is the so-called Brocklebank Dock, 226 ft. long and 64 ft. wide, a reinforced structure built in 1908 on the Hennebique system, and designed to carry the same loading as the Prince's Dock. The test load applied was 9 tons per sq. yd. The piles of this dock are 20 in. square, and had to sustain a load of about 95 tons each, when the test load was applied.

During the first year of its existence there was considerable trouble with the Cattle Wharf and other semi-concrete structures, due to the permeability of the deck-slab part of the structure. The dampness from the salt water entered the permeable concrete and attacked the steel reinforcement on the under side of the slab, causing pieces of concrete to fall off. The defect was overcome by applying a heavy coating of cement to the under side. The upper side of the deck-slab, which is washed daily, shows no signs of deterioration. This emphasizes the fact that great care must be taken in placing concrete in structures standing over or in salt water; there must be the closest inspection during their construction. As a result of this trouble, it appears that the steel reinforcement must be kept farther from the surface of the concrete in salt water concrete structures than in ordinary work. Whereas, at first a minimum of 1½ in. was supposed to be sufficient, the engineers of the London and Southwestern Railway have found this to be insufficient, and are now specifying a minimum of 2 in. for their new structures. Another difficulty encountered was the numerous joints in the Liverpool system of dock construction. This appears to have been overcome by cleaning out the joints and filling them with a rich cement grout, with such success that the docks are reported to be in very satisfactory condition at the present time.

Thames River, Etc.—Within the bounds of the "Port of London Authority," and at other places on the Thames, many reinforced concrete docks or quays have been constructed. One of the most prominent of these is the Thames Haven Jetty Head, near the mouth of the river. This structure was built in 1908, for the berthing of large vessels, and is 136 ft. long and 32 ft. wide. It is supported by 19 columns or piers, 5 ft. in diameter up to low-water mark but of oval shape, 5 by 2½ ft. above. Each column rests on two 15-in. concrete piles of octagonal

section, 45 ft. long, with a penetration of from 18 to 20 ft. After these concrete piles had been driven to refusal, a temporary iron caisson was put down over them. The reinforcing hoops were then lowered into place around the two piles and the caisson was filled with concrete. The caisson was afterward removed, being built in half sections.

Farther up the Thames, 20 miles from its mouth, is the Purfleet coaling jetty, built in 1904, a reinforced concrete structure, 250 ft. long and 34 ft. wide, carrying two heavy traveling cranes. The concrete piles are 14 in. square, from 40 to 50 ft. long, with from 15 to 18 ft. of penetration. The deck-slab is 5 in. thick. The jetty is connected with the mainland by a reinforced concrete approach, over which cars are run to the jetty itself. On one occasion this jetty was rammed by an 8,000-ton steamer, eight piles and 20 ft. of the decking being damaged. That the damage was not more extensive is said to have been due to the firmness of the horizontal decking. In repairing the dock it was necessary to withdraw the eight broken piles and drive new ones. In conducting this repair work, it was especially noticed that the steel reinforcing bars of the original structure showed no signs of rust, though it is well to note that the water at this point of the Thames may be brackish, and not real sea water. The repairs were efficiently made, and the quay is still doing duty.

Another interesting reinforced concrete coaling dock is at Dagenham-Essex-on-the-Thames, 10 miles below London, built in 1901. It is 780 ft. long and 35 ft. wide, and carries eight heavy traveling cranes, weighing 60 tons each, besides a railroad track. Each supporting column consists of three concrete piles encased in a concrete cylinder filled with concrete. Though it may seem a trifle odd, a careful study of photographs of this structure indicates that the tops of the columns are made with "capitals"—a well-proportioned and artistic structure as regards concrete dock work. A similar structure, known as the Prince of Wales Pier, was built in 1903 at Falmouth.

The Thames Iron Works and Shipbuilding Company has constructed at Dagenham a very substantial reinforced concrete dock, designed to carry a concentrated load of 60 tons, for the berthing and fitting out of dreadnought battleships. In the construction of this dock, the Williams type of concrete piles was used for the first time. This type consists of an I-beam surrounded with 3/16-in. wire, 12 in. from centre to centre, the whole being encased in concrete, with special provision at each end to take up the reaction of the driving.

In the same vicinity is the Hornchunk Dock and approaches, built in 1906. The main structure is 400 ft. long and 24 ft. wide, the approach being 280 ft. long and 16 ft. wide; both were built on the Hennebique system. The concrete pile bents are 14 ft. from centre to centre, braced diagonally and support a concrete beam and deck-slab system. Along the water-front side of this dock and its approach, a concrete curtain-wall was built between the piles. This curtain-wall in turn is protected by a wooden fender system. The plans seem to indicate that this structure was designed to carry a 27-ton crane in addition to a 27-ton locomotive.

A reinforced concrete coal dock was built in 1906 at Rochester, on "The Medway," a river flowing into the estuary of the Thames. This dock consists of a main water-front section, 32½ ft. wide and 340 ft. long, connected with the land by two concrete approaches, 100 ft. and 180 ft. in length, respectively. It was built on the Hennebique system, and carries a heavy traveling crane in addition to two railroad tracks. This was one of the first large undertakings in reinforced concrete dock construction on the Thames or its tributaries. At the time it was built it was looked on as the most important structure of its kind in England.

Though the exact number of reinforced concrete docks now in existence on the Thames or its tributaries is perhaps unattainable, it appears that they are more numerous in those waters than in any other part of England.

General.—Perhaps the largest reinforced concrete dock constructed up to date in England is at Swansea, on the southwest coast of Wales. It is a Hennebique design, almost 2,000 ft. long, completed in 1908, the whole structure being built in the dry. Some of its columns are 3½ ft. square. As this structure is used as a coal loading quay, and stands in 40 ft. of water, it is subjected to heavy loads and severe lateral shocks.

At the naval dock yard at Rosyth, Firth of Forth, Scotland, is found one of the most unique and interesting reinforced concrete docks or piers in existence. It is triangular in shape, 620 ft. long, has been finished recently, and forms the entrance pier to a tidal basin. The outer end consists of seven concrete monoliths with a mass concrete fill in the centre, making a solid concrete head, 127 ft. long and 65 ft. wide, covering an area of some 8,300 sq. ft. The rest of the pier consists of twenty concrete monoliths, 25 by 30 ft., supporting a reinforced concrete structure consisting of girders, columns, arches, braces, and deck-beams. The upper decking consists of 3 by 10-in. creosoted wooden joists covered with a creosoted planking arranged so as to prevent any water from collecting thereon. It is a most massive and homogeneous structure, well capable of absorbing any heavy stresses it may receive from warships lying alongside.

In the Bay of Bristol, at Clevedon, where the tide has a rise and fall of some 49 ft., there is another interesting reinforced concrete structure, in the nature of a landing stage. It is 95 ft. long and rests on 22 reinforced concrete piles. The piles, extending up to low-water mark only, were driven through the marl until they reached hard rock. On top of these piles the reinforced concrete landing stage was erected, a structure consisting of columns, beams, bracing, and four different decks or landings.

A reinforced concrete dock of magnitude was recently constructed at Port Talbot. Being designed for coaling operations, it is subjected to heavy loads. The designed load was 850 lb. per sq. ft., the test load being 1,390 lb. per sq. ft., covering an area of 720 sq. ft. The outer row of piling consists of two 14-in. square piles encased in a concrete cylinder, 4 in. thick, and 4 ft. 6 in. in diameter. There are six such columns at the face of the dock. Each of the other two rows consists of eight 14-in. square piles. At this port there are also a number of similar structures, the first having been built in 1907.

It is of interest to note that one of the reasons which influenced the engineers in adopting reinforced concrete for the coaling jetties and wharves at Port Talbot Docks was an extensive fire in one of the docks, due to fuel oil which had escaped from one of the vessels. The oil was ignited through carelessness, and caused a very intense blaze over an area of about 250 by 50 ft. though, fortunately, the oil did not spread out under the wooden structures. With the world-wide use of oil as a fuel for the merchant marine, it is well to consider this danger in American wooden dock structures.

Although the Port Talbot Railroad and Dock Company was among the first to adopt reinforced concrete for wharf construction in England, and so was adversely

criticized "for using an alleged untried material in such types of work," the results obtained have fully justified this radical departure from what was at that time the prevailing practice the world over.

Scattered all through other English ports are reinforced concrete docks of various sizes.

At Fleetwood, from 35 to 40 miles north of Liverpool, a reinforced concrete fish and coaling dock of considerable magnitude was completed in 1911. The fish shed section is 1,330 ft. long and 26 ft. wide, that is, the reinforced concrete quay part; the filled-in land behind the quay makes the shed sections some 70 ft. wide in all. The coaling section, of similar construction and carrying a coal-loading traveling crane, is 680 ft. long and 26 ft wide.

At Harwich, 40 miles northeast of the Lower Thames, is the Parkeston Quay, a reinforced concrete dock structure more than 1,000 ft. long and 51 ft. wide.

On the northeast coast of England, at Newcastle-on-Tyne, a reinforced concrete jetty wharf of extensive size lies along the water-front of a large turret shop.

The port authorities at Dundee and Aberdeen, Scotland, are gradually replacing their worn-out wooden dock structure with reinforced concrete.

On the north coast of Scotland, at Ackergill, stands a life-boat slipway, 194 ft. long, built of reinforced concrete, extending out from the rocky shore into the wide open sea. There are several similar structures in other parts of Great Britain.

A reinforced concrete dock was built in the Shetland Islands in 1910. The head of this dock is 80 by 24 ft., and is reached by a concrete approach, 113 ft. long.

In Cork Harbor and other Irish ports reinforced concrete docks of considerable size have been and are being built.

At Portsmouth, Plymouth, and Cardiff are found the first reinforced concrete docks constructed in England, having been built previous to 1906. They are small, and are used mostly for coaling purposes. Quite extensive reinforced concrete docks, constructed during the last year or two, are found at Newport (Mon.), Swancombe, Gravesend, Portencross, South Bank, Ipswich, Newlyn, and numerous other places.

A number of small reinforced concrete docks or pierheads, other than those just mentioned, exist in England in connecton with shipyards, etc. Such docks are found at Dumbarton Shipyard, on the Clyde, and at several similar establishments.

At first the Hennebique system prevailed in all English reinforced concrete dock construction, but, of late, several other systems have been introduced, the most pronounced of these being the Considère spirally armored concrete piling. Though different types of piles are used in English reinforced concrete dock work, there is a most thorough system of diagonal bracing with each type.

In using the Hennebique or other systems of dock construction, where lateral and diagonal braces of reinforced concrete are put in the structure, it appears that trouble has arisen, and might again arise, from the joints in the bracing system. As the foreign docks built on the Hennebique and similar systems seem to have been a success, it does not perhaps cause as much trouble as it did at first, or would appear to cause. In a concrete structure, of whatever design, built in the water, there is always the danger of cracks below the water line, and these cannot be seen and properly attended to.

In a recent address, Mr. Robert Porter, of "The London Times," stated that "England is one big port." From the vast number of reinforced concrete docks at present in her harbors, it does not seem amiss to say that some day soon the ports of England will be, figuratively speaking, one big reinforced concrete dock, and it will be impossible to enter that country without passing over a structure of this type. In fact, current English technical publications plainly indicate that there is hardly a port of any prominence along her coast where reinforced concrete construction is not now being carried on extensively, to the extent of five heavy coal tip docks in one harbor alone, due to the great economy of such structures over their old wooden predecessors, in the way of maintenance expenses.

In a recent rebuilding of the old wooden docks or wharves at Plymouth, constructed 30 years ago, the engineers of the Great Western Railroad have stated that concrete construction was adopted because "the cost would be about two-thirds of the cost of rebuilding in timber." These new concrete docks rest on Considère piles, and were designed for a live load of 400 lb. per sq. ft.

In closing this description of English reinforced concrete dock construction, it is well to take note of a few points in favor of this type, as set forth by an English engineer from his experience in that field: (1) Easy to build; (2) indestructibility; (3) small cost of annual maintenance; and (4) easy to repair.

QUAY WALL AT VICTORIA, B.C.

The contract will shortly be let by the Department of Public Works at Ottawa for the construction of a quay wall and for a large amount of excavation work in Victoria harbor. Tenders were called on June 4th and closed on June 27th. According to the plans, a sea-wall about 1,000 ft. in length is to be built in the inner harbor at Victoria, it being part of the large revetment scheme of the Dominion Government. It will extend from Songhees Point to the abutment of the Johnson Street bridge, and will facilitate the filling in of an area of over 13 acres that lie between it and the natural shore line. The foundation for the wall is to extend to a depth of 20 ft. below low tide, and will entail the removal of over 65,000 cu. yds. of excavation work. The foundation will consist of a lower layer of rubble about 3 ft. in thickness, over which will be placed broken stone in a layer about 1 ft. thick, which will be carefully levelled to provide a base for reinforced concrete cribs. These cribs will be constructed on a dry dock and will be towed to the site and sunk into position. This is the usual practice in work of this nature on the Pacific coast, and several references have been made to it in these columns of late in connection with other harbor and dock developments. The cribs will vary in length from 80 ft. to 100 ft., and will be 25 ft. wide by 30 ft. in height. The reinforced concrete walls and bottom of each will be 15 in. thick. The interior will be divided into sections by partitions 10 in. thick, and will, when placed, be filled with rubble. The cribs, when in position, will extend in a straight line for the full length of the wall.

With these cribs as a substructure the quay wall will be built in sections about 30 ft. in length and with an average height of 37 ft. above the foundation. Its top will project approximately 7 ft. above high water, and the fluctuation in water level is about 10 ft. at this point. Protection on the face of the quay will consist of 12 in. x 12 in. creosoted fender timbers wedge-bolted into the concrete on 10 ft. centers, spaced by three lines of walings, 10 in. x 12 in.

FOURTH AMERICAN ROAD CONGRESS, NOVEMBER, 1914.

THE mayor of Toronto has been requested by the Hon. A. B. Fletcher, president of the Fourth American Road Congress, and state highway engineer of California, to name three delegates to attend the sessions of the Congress at Atlanta, Georgia, during the week of November 9th.

Forty-seven organizations are taking part in the Congress under the leadership of the American Highway Association and the American Automobile Association. In his letter to the mayor, President Fletcher calls attention to the fact that practically every state highway commissioner will be present and take part in discussing the important problems of road construction and maintenance, and that some of the foremost men in public life will devote their attention to the great question of federal aid to road improvement, in an endeavor to work out a policy which may be submitted to the Congress of the United States with the support of the organized road movement of America. An important move bearing upon state legislation will be made at the session to be held under the auspices of the American Bar Association, at which a joint committee, appointed at the 1913 Congress, will report progress in compilation and suggested revision of state road laws. The creation of a commission participated in by each state to work out a revision of the road laws will be urged. The National Civil Service Reform League will hold an exceedingly important session on the merit system in road administration.

President Fletcher calls attention to the exhibits to be made by the United States Government, the States, and more than a hundred of the leading manufacturers at the Congress, which will illustrate every known method, material and equipment for road construction and maintenance. He urges that the city and county be officially represented, as the Congress is in reality a training school where a very great amount of useful information can be obtained through attendance at lectures with leading specialists in road and street work, and the collecting of the many instructive bulletins which will be available for distribution.

The following is a partial list of papers and addresses to be presented:

General Addresses.—Fairfax Harrison, President Southern Railway; Logan Waller Page, Director U.S. Office of Public Roads; Col. E. A. Stevens, State Highway Commissioner of New Jersey; Brig. Gen. Wm. T. Rossell, U.S.A., retired; James R. Marker, State Highway Commissioner of Ohio. Others to be announced.

Drainage Structures—By W. E. Atkinson, State Highway Engineer of Louisiana. Discussion opened by Frank S. Rogers, State Highway Commissioner of Michigan.

System in Road Management—By C. J. Bennett, Highway Commissioner of Connecticut. Discussion opened by Paul D. Sargent, State Highway Engineer of Maine.

Maintenance Methods and Relation to Traffic—By George W. Cooley, State Highway Engineer of Minnesota. Discussion opened by H. R. Carter, State Highway Engineer of Arkansas.

Convict Labor—By George P. Coleman, State Highway Commissioner of Virginia. Discussion opened by J. E. Maloney, State Engineer of Colorado.

Rights of Way—By Austin B. Fletcher, Highway Engineer of California.

Efficiency in Highway Organization, Centralization of Purchases, Etc.—Discussion opened by John S. Gillespie, Road Commissioner of Allegheny County, Pennsylvania.

Surfaces for Light Volume Mixed Traffic—By S. Percy Hooker, State Superintendent of Highways of New Hampshire. Discussion opened by S. D. Foster, Chief Engineer State Highway Department of Pennsylvania.

State Control of Road Work as a Policy—By A. N. Johnson, Former State Highway Engineer of Illinois. Discussion opened by T. H. Macdonald, State Highway Engineer of Iowa.

Engineering Supervision of Road Construction—By W. S. Keller, State Highway Engineer of Alabama. Discussion opened by R. C. Terrell, State Highway Commissioner of Kentucky.

Economics—By J. E. Pennybacker, Chief Division of Economics, U.S. Office of Public Roads.

Educational Field for Highway Departments—By Dr. Joseph Hyde Pratt, State Geologist of North Carolina. Discussion opened by Col. Sidney Suggs, State Highway Commissioner of Oklahoma.

Heavy Traffic Roads—By Henry G. Shirley, Chief Engineer, State Roads Commission of Maryland. Discussion opened by W. A. Hansell, Superintendent of Public Works, Fulton County, Georgia.

Grades and Excavation—By A. D. Williams, Chief Road Engineer of West Virginia. Discussion opened by William J. Roy, State Highway Commissioner of Washington.

National Legislation—Addresses by: Hon. John H. Bankhead, United States Senate; Hon. Dorsey W. Shackleford, U.S. House of Representatives; Hon. William P. Borland, U.S. House of Representatives. Others to be announced.

CANADA'S STEEL INDUSTRY

Replying to an inquiry as to how the European war would affect the Dominion Iron and Steel Company's plant, Mr. J. H. Plummer, president of the company, said:—

"We have a considerable tonnage of rail orders on our books, but they are chiefly for shipment by water. The disturbed condition which affects the sending of material by sea and the further disturbance of financial arrangements of our customers caused by the war would seem to make it inexpedient to continue rolling on these orders.

"We already have several cargoes awaiting shipment, and more or less held up by those conditions. We think it probable, therefore, that we shall have to shut down much of the plant, or rather to suspend a major part of our operations for a time until we see more clearly what conditions we have to meet.

"In time of war the general iron and steel industries are usually very active and that effect is likely at this time to be more marked in neutral markets because the great centres of industry in Europe are all directly involved. It is difficult to say how this would affect us in Canada, but if there is an active market in the United States we shall follow them to a greater or less degree.

"At the moment we are preparing to damp down two of the blast furnaces now in blast, and the open hearth furnaces. The finishing mills can and will be operated so far as orders are obtainable. We have on hand a supply of billets sufficient to keep these in full operation for some months. The demand for coal is unlikely to fall off, and unless our transportation arrangements should be seriously interfered with, this portion of our business will continue without change."

President Harris of the Nova Scotia Steel Company has announced that as a result of the financial situation created by the war it has been decided to close down a portion of the plant at Wabana Mines and the blast and open hearth furnaces at Sydney mines have been temporarily stopped.

ROAD-BUILDING AND DRAINAGE WORK IN SASKATCHEWAN.

DURING the present season the Board of Highway Commissioners of Saskatchewan is undertaking a considerable amount of drainage work, which will result in the addition of much valuable agricultural land to the municipalities in which the works are situated. Five schemes are now under way, namely, at Rouleau, Invermay, Margo, Rama and Yorkton, while others are being advertised at Kuroki and Canora.

The scheme which will render available the largest amount of land is at Rouleau, and this work is at the point of completion. The work at Invermay, Rama and Yorkton will probably be all finished by the end of August. All of the works are being done by contract under the drainage Act. The schemes in every case went through without difficulty, as there were not enough appeals against the assessments to block any of them. Under the drainage Act the expense is borne by the owners of the lands affected, and also by the rural municipalities whose roads may be benefited. The cost is in the first place met by the government, which is repaid by debentures covering a period up to twenty-five years.

Road-Building.—The carrying out of the road-building programme of the board for the year 1914 is progressing very satisfactorily. Over 100 road gangs have been actively engaged in various parts of the province, and it is considered that the standard of the work being done this year is higher than has been achieved in any former season.

The payment of direct money grants to rural municipalities for road work was found to entail many disadvantages, chief amongst which was a lack of uniformity in construction methods, and it has accordingly been almost entirely discontinued. Some eight rural municipalities, however, had entered into a three-year contract with the board, whereby they receive a grant up to $5,000 in each year on the dollar-for-dollar basis. With these exceptions the work is done almost entirely by the government gangs, although in some cases contracts have been let, where the work was of sufficient magnitude and of such nature as to permit of contracts being awarded economically. About twenty other rural municipalities were found to have well-equipped and competent road gangs, whose work during the last year was fully up to the required standard. The board retained the services of these organizations, and put them to work in the regular way under its own inspectors, and the workmen will be paid direct by the Commission off pay-sheets submitted.

Rural municipal councils have scarcely done as much as they ought in the way of maintenance of roads that have been built, but still there is a noticeable improvement in this respect. Municipalities that show themselves alive to their responsibilities as to maintenance will in future have better chances for assistance from the board. From year to year farmers see the advantages being derived from the use of the road-drag, and its educative effect, which is of the highest, is bound to make itself felt.

Road-Dragging.—At a recent meeting of the Board of Highway Commissioners the matter of maintenance was very thoroughly discussed, and it was regretted that so many rural municipalities appear to have overlooked their responsibilities in connection with maintenance of works undertaken not only by the board, but also out of their own funds. It was decided to send a general letter to all municipalities pointing out to them that it is considered waste of money to improve roads and afterwards let them fall into ill-repair.

The board started a road-drag competition with the sole object of proving the value of this simple implement as a road-maintainer, and it was hoped by the numerous examples scattered throughout the province that the practice would become general, and that every municipality would at an early date see the advantages to be derived from its use.

A great many municipalities have already inaugurated a systematic maintenance programme for their roads, and it is urgently requested that this matter be dealt with in a substantial way by every rural municipal council in the province.

Interest in this year's road-drag competition is much keener than last year, and this is due not so much to the increased prize money, but because of the splendid results achieved. The province has been divided into six districts, in each of which the same prize money be awarded, and all of them are eligible for the $400 championship prize. The list of rural municipalities entered are 68, in all, covering 209 miles of road.

NEW ELECTRIC CRANE CONTROLLERS.

The Westinghouse Electric and Manufacturing Company has recently put on the market a new line of magnet switch crane controllers. This line is complete and includes the following controllers for single motors or for the motors in series or in parallel:—

Trolley; bridge, with or without speed control; and hoist, with or without speed control and dynamic braking.

Dynamic braking is very desirable for hoist operation because it gives the operator complete control over the load. He can hoist or lower at high speed and stop instantly with no over-run, and he can "inch" the load with precision.

The controllers are characterized by reliability, durability, and simplicity. The magnet switch contacts cannot stick together. The parts are few in number and all are strong and substantial. The number of interlocks, with their multiplicity of contacts and complicated connections, is reduced to a minimum. Inspection and repair of wearing parts can be easily made so that time lost on account of controller repairs is negligible. Each switch is mounted on an individual slate base and the whole assembly is mounted in a very substantial manner on a pipe frame work.

Overload protection is provided for by means of two overload relays (one in each side of the line). After the relays have operated, they are automatically reset by bringing the master switch to the "off" position. Since these relays open both sides of the line, failure of operation due to grounded wires is made impossible.

The no-voltage release opens the control circuit on failures of the supply voltage and the motor cannot be started again until the master switch is returned to the "off" position.

In order to secure safety during inspection and repair of crane apparatus, there is a device for locking the main line switch employed. The switch is locked open when the safety key is removed and cannot be closed until the latter is replaced. Several holes are provided for padlocks, which may be inserted by men working independently on the apparatus and prevent the insertion of the safety key as long as they remain in place.

RAILWAYS IN PERU.

Very little progress has been made in the construction of railways in Peru, owing principally to the mountainous nature of the country, which makes it both difficult and costly. The only addition in recent years has been the Lima to Huacho Railway. There are in course of construction a line from Cuzco to Santa Ana and another from Lima to the small port of Chilca. No work has as yet been begun on the projected railway to navigable waters of the River Ucayali.

SURGE TANK PROBLEMS II.

CONTINUATION OF ANALYSES OF PROBLEMS ARISING FROM SUDDEN SHUT-DOWN AND SUDDEN OPENING OF OUTFLOW.

By PROF. FRANZ PRASIL

Authorized Translation by E. R. Weinmann and D. R. Cooper, Hydraulic Engineers, New York City

Special Case of Sudden Shut-Down (Continued).

(2) Graphical Demonstration.—For the graphical demonstration of the velocity, a very simple construction may be used. We may divide the equation 32 into two equations which, using $\varphi = t/T_1$, may be written:

$$B = Re^{-\frac{T_1}{2T_0}\cdot\varphi} \qquad y = B \,.\, \sin(\beta + \varphi) \qquad (47)$$

The former gives in the polar system of co-ordinates (Fig. 3) (φ in radians) with β as the vector radius a logarithmic spiral with the slope $\alpha = -T_1/2T_0$.

The second equation may be demonstrated in the rectangular system of co-ordinates, where y and therefore z is a function of φ, if we consider the axis of abscissæ in the continuation of this ray of the polar system, which is turned from the initial point with the angle β, and if we plot from an initial point in that system the values of φ projecting the points of the spiral on the ordinates which apply to the same values of φ. As $\varphi = \frac{t}{T_1}$, the time may be measured as abscissæ showing the water surface fluctuations with respect to time.

The equation 35, which determines s, has the same form as equation 32. It follows that for the graphical demonstration of s, the same method may be applied as s becomes o when $t/T_1 = \gamma - \beta$ and we see that the axis of the abscissæ for the rectangular system of co-ordinates which demonstrates s, is in the continuation of that ray of the polar system which corresponds to the maximum and minimum values of z and also of y. By projection of the points of the spiral to the corresponding ordinates, we get the z curve, whose ordinates, as may readily be seen, cannot be measured by the same scale as those of the z curve. We have to take: If (for the z curve) an ordinate of one inch equals m feet, then for the s curve an ordinate of one inch $= \frac{m}{T}$ feet per second. The demonstration of the acceleration is similar.

(3) Practical Example.—We may now compute for this case an example to which the graphical demonstration also applies. The dimensions are the following:

$L = 9{,}050$ feet $\qquad p = 32.8$ feet
$a = 80$ square feet $\qquad Q = 530$ cubic feet per second

For a flow of 530 cubic feet per second, according to the usual method of computation, a friction coefficient $K = 101{,}000$ in the formula $h = \frac{L.a}{K.p}\,.\,v^2$ and, therefore, $v_1 = 6.63$ feet per second and $h_1 = 9.6$ feet, are determined.

The surge tank section may be constant and $A = 5{,}380$ square feet. According to the theory, we assume that $h = n.v$, $n = \frac{h_1}{v_1} = 1.45$ sec. $= \frac{9.6}{6.63}$. Therefore, except for the conditions $v = o$ and $v = v_1$, the friction is greater than it would be according to the friction formula commonly used $h = \frac{L.a}{K.p}\,v^2$. If we take

$$\frac{L.a}{K.p} = n^1 \qquad h = n^1v^2 \qquad n^1 = \frac{h_1}{v_1^2} = \frac{9.6}{43.96} = .22.$$

Thus we get for equal values of v the difference $v\,(1.45 - .22\,v)$ which, for $o < v < 6.63$, is always greater than zero.

The assumption $h = n.v$ is right in so much as by the derivation of the principal equations the dampening influences of the friction and the water quantities in the surge tank were not considered.

We compute now the example assuming a complete shut-down, therefore $\epsilon = o$.

$$T = \sqrt{\frac{9050 \times 5380}{32.2 \times 80}} = 137.5 \text{ sec.}$$

$$T_0 = \frac{9050}{1.45 \times 32.2} = 194.5 \text{ sec} \qquad T_1 = 147 \text{ sec.}$$

$$R.\sin\beta = -(1-\epsilon)\,h_1 = -9.6 \text{ feet.}$$

$$R.\cos\beta = (1-\epsilon)\left(\frac{T_0}{T^2} - \frac{1}{2T_0}\right) h_1\,T_1 = 10.9 \text{ feet.}$$

$$R^2 \sin^2\beta = 92 \quad tg\beta = -\frac{9.6}{10.9} = -.881 \quad \beta = -41^\circ\,24'$$

$$R^2\cos^2\beta = 119$$

$$R^2 = 211 \qquad \text{arc}\,\beta = -.722$$

$$tg\gamma = \frac{2T_0}{T_1} = \frac{389}{147} = 2.65 \quad \gamma = 69^\circ\,18'$$

$$R = 14.54 \text{ feet} \qquad \text{arc}\,\gamma = 1.21$$

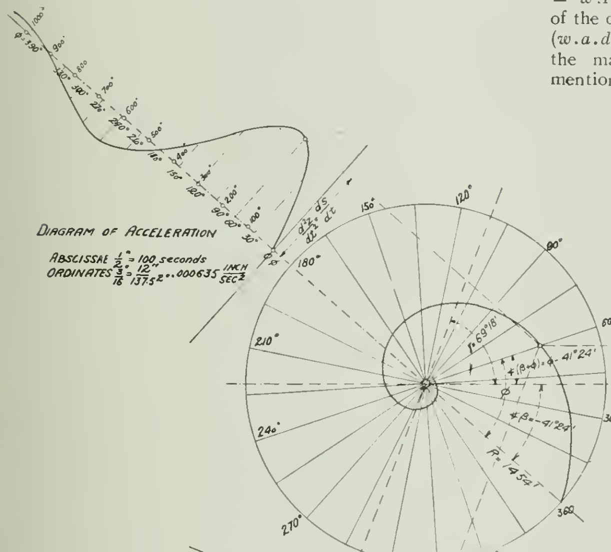
$$z = 14.54\,e^{-\frac{t}{389}} \sin\left(\frac{t}{147} - .722\right)^*$$

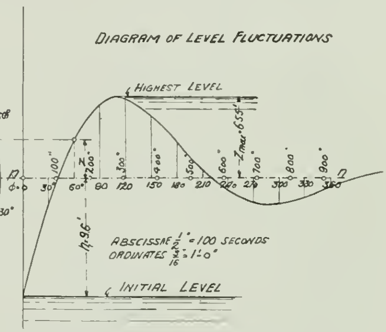
*The proportion t/T_1 is in radians, but must be changed into the usual measurements as soon as we use the trigonometric functions.

$$s = .106\, e^{-\frac{t}{389}} \sin\left(1.932 - \frac{t}{147}\right).$$

The values (in seconds) for the first occurrence of the maximum and minimum are

t_1 max $= (\gamma - \beta)\, T_1 = [1.21 - (-.720)]\ 147 = 284$ sec.
t_1 min $= (\gamma - \beta + \pi)\, T_1 = (1.93 + 3.14)\ 147 = 746$ sec.





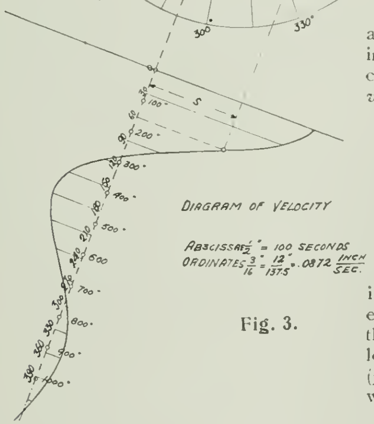


Fig. 3.

z max I. $= 6.55$ feet, $\quad z$ min II. $= -2.00$ feet,
$\delta = 2\pi T_1 = 924$ sec. $= 15$ min. 24 sec.

The graphical demonstration using these values shows very clearly the water level fluctuation in the surge tank in function of the time (Fig. 3 and Fig. 4).

(4) Work Done.—For the case of a sudden complete shut-down, it is interesting to strike a balance of the work done. The basis for such a balance may be secured by a variation of the principal equation 16, considering also the continuous equation 17. If we multiply the equation 16 by $(w.a.v\,dt)h$ we get

$$\frac{w\,a\,L}{g}\, v\,dv + (w\,a\,v.dt)\, z + (wavdt)h = o$$

$$\frac{w.a.L}{g} = M = \text{mass of the}$$

main conduit volume and for $\epsilon = o$, $w.a.v.dt$ becomes $= w\,A\,s\,dt = w.A\,dz = dG$, i.e., the increase of weight of the contents of the surge tank during the time dt. Also $(w.a.dt\,v)\ h = A^1 =$ to the amount of friction work in the main conduit during the time dt. The above-mentioned equation becomes

$$M\,\frac{dv^2}{2} + z\,d\,G + dA^1 = o$$

and the integration between the limits which refer to the initial condition and to the highest elevation for z max., considering that at the beginning $v = v_1$ and at the end $v = o$:

$$-\frac{Mv_1^2}{2} + \int_{-h_1}^{+z\max} z\,d\,G + A^1 = o \qquad (49)$$

We may place

$$\int_{-h_1}^{+z\max} z\,d\,G = G.z_1$$

if we consider G as the weight of the water that has entered the surge tank during that period and if z_1 is the distance of the centre of gravity of G above static level $n - n$. But we may as well say $z_1 = y_1 - h_1$ (50) (y_1 = distance of the centre of gravity of G from the initial water level). It follows then, that

$$\frac{Mv_1^2}{2} + G\,h_1 = G\,y_1 + A^1 \qquad (51)$$

This is the equation for the work done, which is correct also when the cross-section A is variable. As potential energy, we must introduce: (1) The kinetic force of the volume of the main conduit, and (2) The potential energy of the weight G due to the first difference of level h_1 between the elevation in front of the forebay, (i.e., the static level $n - n$) and the initial level.

As used work we must introduce:

(1) The lifting work due to the lift of the weight G through the height y_1.

(2) The friction work.

We may strike the balance in the following manner:

Useful work in foot-tons.		Used work	
15800	Kinetic Energy of the Conduit Contents		$\frac{62.5 \times 80 \times 9050}{32.2} \times \frac{6.63^2}{2}$
26600	Potential Energy of G = 2770 Tons for h_1 = 9.6 Feet		5380 (9.6 + 6.55) × 62.5 × 9.6
	Lifting Work for 2770 Tons for height of 8.07 Feet	22400	$\frac{16\ 15}{2} \cdot 2770$
	Friction work	20000	42,400 — 22,400
42400		42400	

The total friction work of 20,000 foot-tons corresponds to an average friction head corresponding to the conveyed weight of 2,770 tons.

$$h_1 \text{ (average)} = \frac{20{,}000}{2{,}770} = 7.22 \text{ feet} = .752 . h_1 \quad (52)$$

We might use this result to determine the necessary surge tank volume in a similar case, if in the equation 51 we write: A^1 is similar to:

h (average) . G which must be equivalent to $.752\ h_1 G$

A supplementary formula to determine the value h (average) follows in the final chapter.

Case B.—Sudden Opening.

Before the beginning of outflow through the penstock, the water in the main conduit and in the surge tank is quiescent. The water surface in the surge tank is at the level $n - n$ and z = zero. As soon as the opening occurs, which is considered as taking place instantaneously, the outflow begins. However, the full amount of the outflow does not occur instantaneously because of the inertia of the mass; also during the time following the opening, q will not be constant even with a constant opening, as with the variation of the water surface elevation the slope due to the outflow velocity also varies. As in case (A), where we assumed that all these influences and variations are a very small amount, we consider q as constant from the instant that the opening occurs.

The following will now happen at this juncture: Immediately after the opening the water surface in the surge tank goes down. The head, due to this difference between the water level in the main conduit and that in the surge tank, creates a movement in the main conduit, but on account of the inertia of the mass and the increasing friction, the velocity does not increase in the same proportion as the drop of the surface in the surge tank below the static level $n - n$. On this account the water surface in the surge tank goes below the level which corresponds to the normal water level for a constant flow. So that we have first a dropping down to a lowest level whereas afterwards there occurs a damped oscillation, until finally, under the influence of all resistances, a normal balanced condition is reached, where the level in the surge tank is as much under the level $n - n$ as the amount of head required to create the necessary slope.

The initial equation 23 has in this case (if we say $q = \epsilon Q_1$ for purposes of comparison) the same form as in case (A) and therefore all other equations (growing out of equation 23) also apply. The determination of the integration constant will, however, give other values for R and β since the initial condition is different. We have at the time t = zero, z = zero, and $s = s_0 = -\frac{Q_1}{A}\epsilon = -\epsilon . C_1$. For the determination of the constants R and β we get the equations:

$$R . \sin\beta = +\epsilon h_1; \quad R\cos\beta = -\epsilon\left(C_1 - \frac{h_1}{2\,T_0}\right) T_1 \quad (53)$$

The same procedure as in case (A), referring to the signs of $\sin\beta$ and $\cos\beta$, shows in this case that β lies in the second quadrant, if $\frac{A}{a} < \frac{2\,L}{n^2 g}$, and in the first quadrant when $\frac{4\,L}{n^2 g} > \frac{A}{a} > \frac{2\,L}{n^2 g}$.

We get, further,

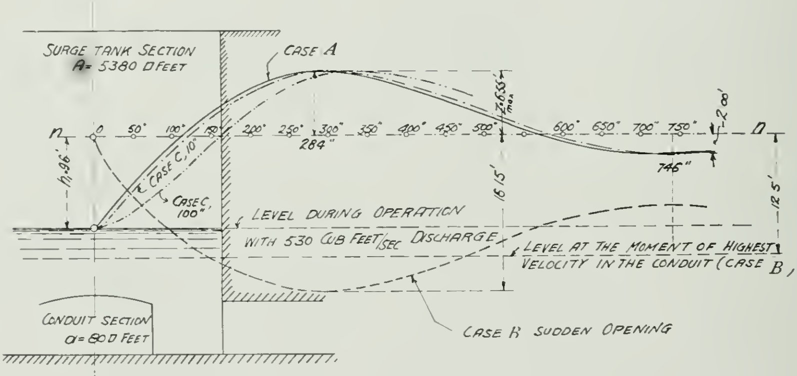


Fig. 4.

$$R = \epsilon h_1 \frac{T_1 T_0}{T^2} \quad tg\,\beta = -\frac{1}{T_0/T_1 - \frac{1}{4}\,T_1/T_0} \quad (54)$$

If we open the penstock so that the outflow has the full value $q = Q_1$ ($\epsilon = 1$) then R assumes the same value as in case (A) for a complete shut-down. β has in both cases the same form, therefore, (referring to the above-mentioned investigations) it follows that the initial radius vector in the polar co-ordinate system for the case (B) is turned through 180° from case (A). The duration of the period is the same as in case (A). The graphical demonstration may be begun also from the same spiral with the slope $tg\,\alpha = -T_1/2T_0$. The analytical results (assuming a full opening from zero to 530 cubic feet per second, that is, $\epsilon = 1$, $n = 1.45$ sec., assuming the same dimensions) are as follows:

$T = 137.5$ sec. $T_0 = 194.5$ sec. $T_1 = 147$ sec.
$R = 14.54$ feet $\beta = 180 + (-41^\circ\,24') = 138^\circ\,36'$
arc $\beta = +2.420$

$$z = -9.6 + 14.54\,e^{-t/389} \sin(2.42 + t/147)$$

$\gamma = 69^\circ\,18'$ arc $\gamma = 1.210$

$$s = .106\,e^{-t/389} \sin(-1.21 - t/147)$$
$$= -.106\,e^{-t/389} \sin(1.932 - t/147)$$

Therefrom we determine the time for the first minimum of z

t_1 min $= 1.932 \,.\, 147 = 284$ sec.

and for the first maximum:

t_1 max $= (1.932 + 3.142)\;147 = 746$ sec.

These are the same values as were reached before for the occurrences of the first maximum and minimum. Finally follows

$z^1_{min} = -9.6 - 6.55 = -16.15$ feet;
$z^1_{max} = -7.6$ feet.

As z^1 max is negative, we see that with the assumed dimensions and for full opening to 530 cubic feet-seconds, the water surface does not rise any more above the level $n - n$ after the first dip. (Fig. 4.)

The velocity in the main conduit at the time of the greatest drop becomes $v_1 = Q_1/a$ but the velocity increases continuously thereafter, as in the following period of rise of the water surface, besides the outflowing quantity Q, also that water from the main conduit which is necessary for the refilling of the surge tank has to flow in. And the increase lasts until v becomes a maximum. Because $v.a = s\,A + Q_1$ the velocity v becomes a maximum if s is a maximum and we get:

$$s \text{ max} = \frac{R}{T}\,e^{-\frac{\pi T_1}{2\,T_0}} .\sin\gamma = .03 \text{ feet per second.} \quad (55)$$

$$v \text{ max} = \frac{A}{a} \,.\, s \text{ max} + v_1 = 8.65 \text{ feet per second.}$$

The conclusion of practical value is that the greatest drop below the static level $n - n$, resulting from a sudden full opening, reaches the same value as the greatest rise from the initial level for a sudden full shut-down.

(To be continued.)

DESIGN OF INTERCEPTERS FOR A LARGE SEWERAGE SYSTEM.

THE recently issued progress report on the plan of sewerage for the City of Cincinnati contains a number of important solutions to problems typical of those to be found in large sewerage systems. The report, to which we have previously called the attention of our readers, is most complete in that it contains all data used in connection with the development of the system and the projected improvements.

One of the outstanding sections is that descriptive of the design of the new intercepting sewers. This section was prepared by Mr. E. J. Miner. The designs were worked out under Mr. Victor T. Price, Director of Public Service, and Mr. Henry M. Waite, chief engineer. Mr. H. S. Morse was engineer in charge of all sewerage investigations and Mr. H. P. Eddy was consulting engineer.

The following study of the Cincinnati requirements

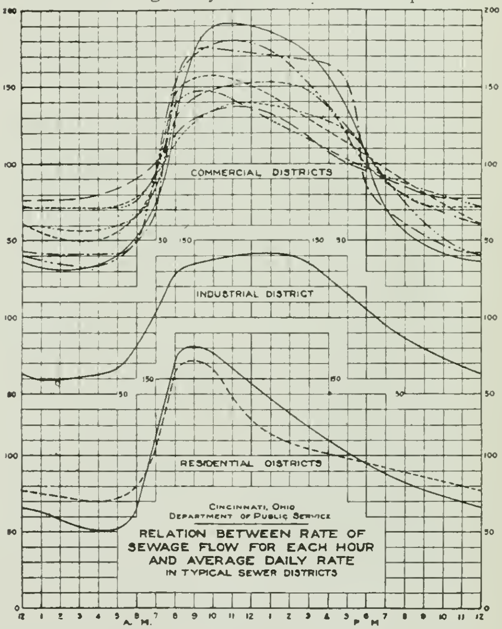


Fig. 1.

and of the resulting design will undoubtedly be found of considerable service.

General Problem.—The present sewerage system consists of a large number of disconnected sewers, each serving a limited district. In some cases these districts are very small; in others, very large. Each sewer has been constructed to discharge into the nearest water course thought adequate to take away the sewage. Nearly all of the existing sewers are built on the combined system, during dry weather the sewers discharging domestic sewage into the streams and during storms, street washings and roof water, combined with the sewage.

In the case of districts adjoining the Ohio River this method of discharge has not in general proved objectionable. As a rule, the trunk sewers empty into the river below the water level, so that, except in the immediate vicinity of the outlet, the fact that sewage is being discharged into the river is hardly noticeable. In the case

of the small streams flowing through the city, however, conditions are very different. During dry weather these streams carry very little water, and the result is that the sewage flow constitutes a sufficient percentage of the water flowing in the streams to be noticeable and offensive. Stagnant pools of putrifying sewage are not uncommon, and during the dry months these streams are a menace to the health of the community. At times of storm the accumulated sewage is flushed out and carried to the Ohio River.

With the exception of the sewers discharging into the Ohio River, practically all of the sewage of the city is discharged into Mill Creek and its tributaries and Duck Creek. These two streams receive at least 65 per cent. of the sewage of the city, and are accordingly in very bad condition.

It is necessary to provide intercepting sewers to receive the sewage from the trunk sewers and to convey it to a suitable point of disposal. These intercepters were designed not only to receive sewage from the existing and future sewers, but to convey it to a point where it may be discharged without offense, or treated in such a way that the resulting effluent may be discharged into the streams.

There are at present a few sewers which are called intercepters and which serve to some extent as intercepting sewers. They receive the dry weather discharge of one or more sewer districts and convey it to a point where the stream flow is assumed to be greater, so that the dilution of the sewage is more thorough. These sewers will serve as branches to the main intercepters which will be required in any comprehensive scheme.

Disposal by dilution will be sufficient for the present. It may be, however, that ultimately the discharge of untreated sewage into rivers and streams will be prohibited by law, and to fulfil sanitary requirements it will be necessary to treat all sewage before its discharge into streams. Accordingly, the intercepters have been designed with a view to the ultimate collection of the sewage at suitable sites for such treatment as it may require.

Collection of Sewage.—Intercepting sewers following in a general way the course of the streams into which the trunk sewers now discharge will be necessary to collect the sewage from the several sewer districts. It is obvious that three main intercepters or systems of intercepters will be required: one in Mill Creek Valley, one in Duck Creek Valley and one following the bank of the Ohio River.

In such a case as the Mill Creek Valley it is sometimes practicable or desirable to construct two or even three intercepters. For instance, conditions might make it desirable to build high level intercepters at the edge of the high land on both sides of the stream, each of which would intercept the greater part of the sewage tributary to the stream from its side. The third intercepter, which might not be needed if the valley below the high land were not developed, would closely adjoin the stream and would receive the sewage from the districts lying below the high level intercepters. Such a project is particularly desirable where pumping the sewage is necessary, in order to collect as much of the sewage as possible at a high level and thus reduce the amount to be lifted or the height to which it must be pumped. This method was not found practicable for Cincinnati, and it is planned to construct a single main intercepter closely adjoining Mill Creek, a similar one near Duck Creek and a third along the bank of the Ohio River.

Economic Period of Design.—In designing intercepting sewers it is obviously necessary to make provision for a reasonable amount of growth in order that they may not be soon outgrown. It is also necessary, first, that engineering works should not be constructed on too large a scale, so that they cannot operate efficiently under present conditions, and, second, that expense of construction for future requirements should not be so great that the burden of debt imposed at present becomes unreasonable. It may readily be seen that in some cases the saving of expense resulting from providing works sufficient for the present may be sufficient amply to provide for the additional construction that may be made necessary when larger works are needed.

The economic period for which provision should be made in the design of intercepting sewers depends on various conditions, among which the rate of growth of

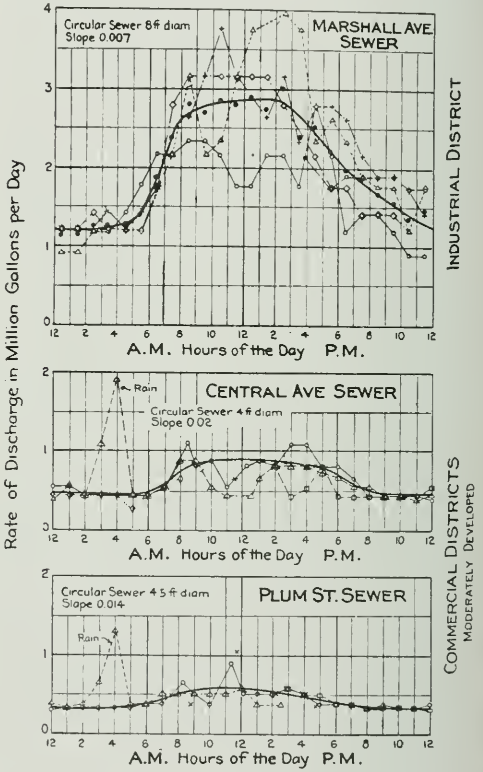


Fig. 2.—Hourly Variation in Rate of Sewage Flow in Commercial and Industrial Districts.

the city is one of the most important, and is a condition which cannot be absolutely fixed. In general, it is desirable to provide for a period ranging from 30 to 50 years from the date of design. In the present study it has been concluded that approximately 40 years is a suitable period for which to make provision and, rounding off the figures, designs have been made on the basis of the requirements of the year 1950.

Area.—From 1802 to 1848 the area of Cincinnati was three square miles. Various small areas were annexed from time to time until, in 1910, the total area was approximately 50 square miles. During 1911 an area of over 16 square miles was annexed to the city and in 1912 the

area annexed was about 3.5 square miles, bringing the total area of the city up to about 70 square miles.

After due consideration it has been decided to base the design of the comprehensive system of sewers upon an estimated future area of about 140 square miles.

Population.—Cincinnati has had an exceptionally slow rate of growth, but the natural advantages, its location and the enterprise of its citizens would seem to warrant the opinion that a more rapid growth will occur in the future. Careful consideration of the data which has been accumulated in connection with this study, and of the local conditions, leads to the conclusion that a comprehensive system of sewers designed at the present time for a period of about 40 years in the future should be based upon a future population of about 720,000 persons and a rate of growth averaging from 20 per cent. per decade in the immediate future to 17 per cent. per decade 40 years hence. The population of the city at the end of each decade, should this estimate prove correct, will be: 1920, 440,000; 1930, 520,000; 1940, 615,000; 1950, 720,000.

By basing the designs for a sewerage system upon these estimates provision is made for a future population approximately twice as great as that of Cincinnati at the present time.

As a basis for computing the quantity of sewage to be provided for by the intercepting sewers, the estimated future population was distributed among the several sewer districts.

The boundaries of each voting precinct and of the several sewer districts were plotted upon a map, scale of 1,000 ft. to 1 in. By combining the populations in the several precincts and parts of precincts within a given sewer district the total population now residing in each sewer district was determined. In determining the density of population in the various districts allowance was made for unpopulated areas, as parks, cemeteries and railroad yards, by deducting these areas from the area of the district.

Table I.—Density of Population, City of Cincinnati, 1850-1950.

Year.	Population.	Area, sq. miles.	Density, persons per acre.
1850	115,435	6.16	29.3
1860	161,044	6.93	36.3
1870	216,239	19.05	17.7
1880	255,139	23.53	16.9
1890	296,908	23.73	19.6
1900	325,902	35.27	14.5
1910	364,463	50.26	11.3
1912	380,305	69.85	8.5
1920	440,000	82.45	8.3
1930	520,000	99.30	8.2
1940	615,000	119.35	8.1
1950	720,000	141.50	8.0

The areas of the sewer districts vary greatly, the small districts for the most part being those which are directly tributary to the Ohio River and in the older portion of the city. The area of the smallest district is 10.5 acres, while that of the largest well-sewered district is 4,068.7 acres. The present density of population varies from 0.2 person per acre to 104 persons per acre. The estimated future density of population varies from 0.4 person per acre to 110 persons per acre. This is considered to be a liberal basis for the design of the intercepting sewers, as the deficiencies of some districts will offset the excesses of others; but where individual sewer systems are to be designed a more liberal allowance for future growth should be made, because no such compensating conditions can be relied upon for the relatively small sewer districts.

Main Drainage Districts.—The city may be naturally divided into three main drainage districts, that served by Mill Creek, that draining directly into the Ohio River, and that served by Duck Creek; to which should be added two small areas within the estimated future city limits, one of which is naturally drained by Rapid Run and Muddy Creek, and the other by Sycamore Creek. It appears that provision has been made for an estimated future population of over 300,000 persons in Mill Creek Valley and approximately an equal number in the Ohio River District, and that the estimated future population in the Duck Creek Valley is nearly 100,000 persons.

Classification of Future Area of City.—The quantity of sewage contributed from residential areas is much less than that from industrial and commercial areas. To arrive at a reasonable basis of design, a study was made to determine the proportions of the city which in the future will be devoted to residential, industrial and commercial purposes, and to parks and cemeteries. From the last two the quantity of sewage for which provision should be made is very small, being made up chiefly of ground water. As hereinbefore stated, it has been assumed that the area of the city in 1950 will be approximately 140 square miles. With the aid of the opinions expressed by representatives of local real estate firms an estimate has been made of the probable limits of the industrial and commercial areas. The distribution of the area within the assumed limits of Cincinnati as of 1950 is as follows:

Area.	Square miles.	Percentage.
Industrial	12.79	9.04
Commercial	1.13	0.80
Residential	123.30	87.11
Cemetery and park	4.02	2.83
Railroad yards	0.31	0.22
Total	141.55	100.00

Quantity of Sewage to be Handled by the Intercepting Sewers.—The system of intercepting sewers was designed to receive and convey to a point of discharge all of the sewage contributed in 1950 by the several district sewers with which they connect, at times when storm water is not actually running into the city sewers. It is therefore important that the intercepters be large enough to carry the maximum quantity of sewage collected by the trunk sewers. This quantity will vary from hour to hour, from day to day and from season to season. In the spring, when the ground water is high and relatively large quantities of it seep into the sewers, the quantity collected will be large and the intercepters should have sufficient capacity to convey it to the point of discharge. It is not intended, however, to provide capacity in the intercepters for any substantial quantity of actual storm water, the plan being to provide overflows from the trunk sewers, so that when the capacity of the intercepters is reached the excess flow may discharge directly into the neighboring water-courses.

When first constructed the intercepters will have a surplus capacity, intended to provide for the expected increase in area and population of the city, which may be utilized to carry small quantities of storm water so that overflow from the trunk sewers will not take place quite as frequently as in later years, when the normal flow of sewage has reached approximately that for which the in-

tercepters have been designed. The quantity of sewage collected varies greatly from hour to hour, as the report shows by numerous curves of hourly variation in rate of sewage flow in the various districts. It also varies materially from day to day during the week, the smallest quantity usually being produced on Sundays and holidays and the maximum quantity as a rule on Mondays. The quantity of sewage from commercial districts is greatest during business hours, as indicated, Fig. 1.

The quantity of industrial waste fluctuates, depending upon the character of the industry, the condition of business and the hours of work. Paper mills are usually operated throughout the 24 hours, so that the rate of discharge of their wastes is generally fairly uniform from hour to hour. Packing houses, tanneries and woollen mills, on the other hand, are usually operated from 7 a.m. to 6 p.m., except for one hour at noon, and the discharge from such plants is therefore largely confined to those hours. In some industries, however, the processes employed are such that the wastes are discharged by the emptying of vats or otherwise, so that the discharge takes place intermittently, with corresponding fluctuations in the rate of flow.

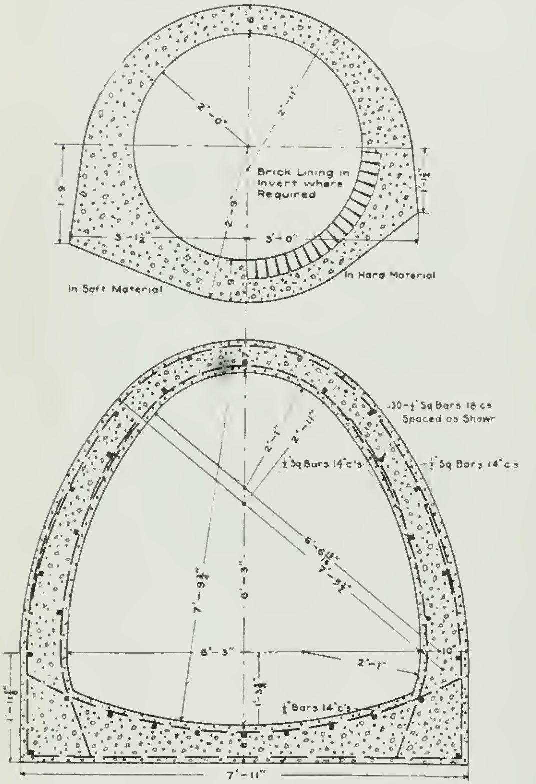


Fig. 3.—Typical Circular and Semi-Elliptical Sections.

The quantity of ground water which finds its way into the sewers varies in a general way with the variations in rainfall. Usually a hard and long-continued rain is followed by a material increase in the flow of sewage, due to infiltration of ground water. In the spring when the frost is coming out of the ground, leaving it more porous than at other seasons of the year, considerable surface water finds its way into the earth, so that the rate of infiltration into the sewer system is then usually much higher than during other seasons. The least quantity of ground water seeps into the sewers during seasons of extreme drought, or during the winter when the ground is securely sealed by frost.

In order that the intercepting sewers may perform their functions it is necessary that they shall have sufficient capacity to carry the sewage, not only on the day and at the hour when the normal flow of sewage is greatest, but also at times when the discharge of wastes from the commercial districts is highest, when the discharge from the industrial districts is a maximum, and also in the spring of the year when the infiltration of ground water is greatest. These maximum quantities may all occur at the same time, so that they must all be taken into consideration in determining the size of the sewers. At the same time it is important not to lose sight of the fact that the maximum rate of flow in the intercepter at any point is not the sum of the maximum rates of discharge of all the contributing trunk sewers.

Ordinarily the maximum discharge from trunk sewers occurs between the hours of 10 a.m. and 2 p.m. If the intercepter is so long that several hours are required for sewage discharged into it at its upper end to reach the point of discharge of the last trunk sewer, near its lower end, the maximum discharge from the lower sewer will have left the intercepter before the maximum discharge from the upper sewer has reached the lower point. In other words, there is a tendency for the peak flows in the several contributing trunk sewers to compensate each other, and on this account the rate of flow in an intercepting sewer is always more uniform than the rates of flow in the contributing trunk sewers. For example, the maximum rate of flow in one Vine Street sewer on a certain date, was 179 per cent. of the average for the 24 hours, whereas it is to be expected that the maximum rate of flow in the Ohio River intercepter, into which that sewer will discharge, will not ordinarily exceed 135 per cent. of the average flow for 24 hours.

Quantity of Sewage from Residential Areas.—The quantity of sewage collected by a system of sewers serving a strictly residential district depends upon the quantity of water used and discharged into the sewers and upon the amount of ground water seeping into them. It is therefore important to take into consideration the consumption of water, as well as to measure the flow of sewage in trunk sewers serving large residential areas in which there are no manufacturing and substantially no commercial districts.

The flow in two such trunk sewers has been measured. It was not practicable to place weirs in either of them, and it was therefore necessary to make measurements of the depth at frequent intervals of time and to compute the quantity from these measurements. These computations have been made by Kutter's formula with $n = 0.015$.

All of the measurements were tabulated and for each sewer the several observations made at the same hour of each day were averaged and smooth curves were drawn to represent these averages. It is believed that these conventional curves represent with reasonable accuracy the rates of flow which may be expected at any hour of the day, between Monday noon and Saturday night, of any week during which the ground water is low and no storm water is reaching the sewers. Similar diagrams in which the rates of flow are shown in terms of per cent. of the

average rate for the twenty-four hours were made from the conventional curves, and are included in Fig. 4.

The measurements of the quantity of sewage produced by the two residential areas showed averages of 92 and 80 gals. per capita per day, respectively, while the maximum rates were 157 and 128 gals. per capita, respectively.

Water Supply.—Very complete records of the quantity of water consumed have been kept by the Water Department. A table was prepared showing the total quantity of water consumed, the quantity of water per capita, the number of services, the number of meters in use and the per cent. of services metered, together with the census, or estimated population served for the years specified. In 1912 47.6 per cent. of the water services were metered.

From the data so compiled it appears that in the last 23 years the minimum daily rate of water consumption was 114.5 gals. per capita in 1890, that the maximum rate was 154.01 gals. per capita in 1895; and the average daily rate for the last 23 years was 130.6 gals. per capita.

During recent years an effort has been made to increase the proportion of services metered so as to check the waste of water, the experience of other cities proving that by the use of meters the quantity of water consumed can be held down to reasonable figures. In Cincinnati the consumption has been considerably higher than in a number of other large cities, but while the tendency of the times is toward a greater per capita consumption, it is expected that if a large proportion of the services are metered the daily rate of consumption will not materially exceed that of the present time, which may be fairly taken to be 125 gals. per capita. It is possible that this rate might be somewhat reduced, possibly to as low a rate as 100 gals. per capita daily. Taking into consideration, however, the tendency towards greater consumption, it does not seem wise to plan for a period of 40 years in the future without allowing for some increase. In these studies it has therefore been assumed that the daily consumption will ultimately, and within the period for which the intercepting sewers are designed, reach 150 gals. per capita.

It is commonly thought that practically all of the water supply eventually reaches the sewers. This, however, is a fallacy, for a very considerable part, probably not less than 40 per cent., is disposed of in other ways. It is evident that the water used for steam purposes, much of that used for manufacturing and mechanical purposes, that used by street and lawn sprinklers and the leakage from mains and services, as well as that used by water consumers not connected to the sewers, fails to reach the sewers.

An estimate of the quantity of water used for these several purposes in Milwaukee was made by the Milwaukee Sewage Disposal Commission in 1911 as follows:

Purposes.	Gals. per capita per day.	Per cent. of total consumption.
Steam railroads	5	4.76
Manufacturing and mechanical	5	4.76
Street sprinklers	5	4.76
Lawn sprinklers	2½	2.38
Consumers not connected to sewers	7½	7.14
Leakage from mains and services	15	14.28
Totals	40	38.08

The percentage of the water used for these purposes in Milwaukee was based upon a total average daily consumption of 105 gals. per capita. Applying the same percentage in Cincinnati, it would appear that the quantities of water given in Table II. would be used for the several purposes indicated in the years 1912 and 1950, respectively.

With an assumed daily use of water of about 150 gals. per capita, 56 gals. of which do not reach the sewers, it has seemed reasonable to take the average quantity of domestic sewage exclusive of ground water, at 90 gals. per capita per day and the maximum rate at which it will reach the intercepter at 135 gals. per capita per day. These estimates seem to be justified by the determinations of the daily flow of sewage in the Mitchell Avenue and Ross Run sewers, which were 80 and 92 gals., respectively, with maximum rates of 128 and 157 gals., respectively, per capita.

Quantity of Sewage from Commercial Districts.—The commercial district in Cincinnati is unusually well defined, and it is served by a number of parallel sewers, each draining a relatively small district, it was deemed wise to make measurements of the flow so that an intelligent estimate might be made of the quantity of sewage which will have to be taken into the intercepting sewers.

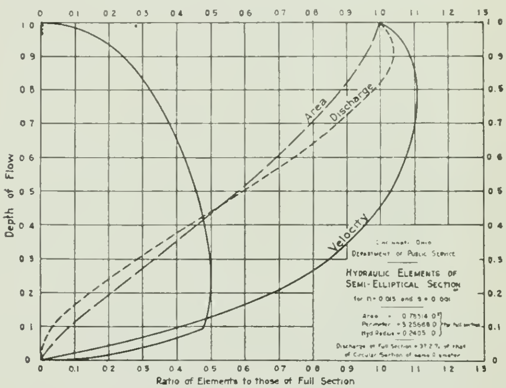


Fig. 4.—Hydraulic Elements of Semi-Elliptical Section (Fig. 3).

Accordingly, measurements were made of the flow in some of the sewers, each of which is between 3,000 and 3,500 ft. in length and serves an area of approximately 35 acres. Several of them, although in the commercial district, have large resident populations. The measurements of the rate of flow of the sewers serving commercial districts were made during the extremely dry season, and it has been assumed that the infiltration of ground water at the time the measurements were made was negligible.

Of the total area of 227.2 acres in the commercial sewer districts gauged, certain districts, with a combined area of 169.3 acres may be considered as highly developed. In these districts will be found hotels, high-class office buildings, department stores and public buildings, with relatively few apartment houses. The streets are paved with asphalt and granite blocks. Other districts, comprising an area of 57.9 acres, may be classed as moderately developed. In these districts will be found smaller hotels, smaller stores, wholesale houses and second-class business blocks, with a considerable proportion of tenement houses. A further area of 133 acres is considered as a semi-commercial area lying around that moderately developed.

The estimation of maximum rate of sewage flow from commercial areas (in addition to sewage contributed by

the resident population, and not including ground water) has been made as follows:

The average of the maximum rate of flow for the six "highly developed" districts above mentioned is 81,508 gals. per acre daily (maximum points taken from conventional curves), which may be taken to fairly represent the maximum flow of sewage per acre from these districts if combined. The area is 169.3 acres, so that the maximum rate of discharge would be 13,800,000 gals. per day. The resident population is 4,744, and the maximum rate of flow of domestic sewage corresponding to this population at 135 gals. per day per capita would be 640,000 gals. per day. The difference, 13,160,000 gals. per day, is taken to represent the maximum rate of sewage flow due solely to the commercial development of the district, equivalent to 77,700 gals. per acre daily.

Table II.—Estimated Quantities of Water Used, But Which Do Not Reach Sewers.

Purposes.	Gals. per capita per day based on total consumption of 125 gals., 1912	Gals. per capita per day based on total consumption of 150 gals., 1950	Per cent. of total consumption
Steam railroads	6	7	4.76
Manufacturing and mechanical	6	7	4.76
Street sprinklers	6	7	4.76
Lawn sprinklers	3	3½	2.38
Consumers not connected to sewers	9	10½	7.14
Leakage from mains and services	18	21	14.28
Totals	48	56	38.08

In the same way the average of the maximum rates of flow for the two moderately developed districts is found to be 26,025 gals. per acre daily, equivalent to a maximum rate of flow of 1,510,000 gals. per day from 57.9 acres. Domestic sewage at a maximum rate of 135 gals. per capita per day for a population of 2,810 corresponds to a maximum rate of 380,000 gals. per day, leaving 1,130,000 gals. per day as the maximum rate of flow from the purely commercial district. This corresponds to 19,500 gals. per acre daily.

No data exist to indicate the commercial sewage which may be contributed from the 133.3 acres of commercial area which is as yet largely undeveloped. It has been assumed that the maximum rate of flow of commercial sewage from this area may be taken as 12,000 gals. per acre per day.

Assuming that the relative proportions of highly developed, moderately developed and substantially undeveloped area will remain practically unchanged, the average maximum rate of sewage discharge from commercial area, due solely to their use for commercial purposes, has been estimated as equivalent to 44,000 gals. per acre daily; or, in round figures, 40,000 gals. per acre daily in addition to domestic sewage from the resident population and ground water.

From the estimated future commercial area of 721 acres the maximum rate of flow has been computed on the basis of 40,000 gals. per acre per day for commercial sewage; 750 gals. per acre per day for ground water, as hereinafter explained, and 135 gals. per capita per day for domestic sewage.

Quantity of Sewage from Industrial Areas.—As certain portions of the city are and will continue to be devoted to industrial enterprises from which large quantities of liquid wastes will be discharged into the sewers, an effort has been made to secure data which might aid in forming an estimate of the quantity for which provision should be made in the intercepting sewers.

It should be noted that there is always a tendency for certain classes of industrial planks, such as packing houses, dairies and the like, to discharge into the sewers large quantities of solid or heavy semi-fluid wastes. Precautions must be taken to prevent the entrance of such matter into the intercepting sewers, if necessary, by requiring all such plants to maintain settling tanks upon their branch sewers.

It is extremely difficult to determine the quantity of wastes which will be discharged from an area devoted to industrial purposes, as the amounts produced by manufacturing establishments vary enormously and because such an area is also developed for residential purposes to a considerable extent. Actual measurements were desired and were made for four districts which were selected for that purpose.

The Marshall Avenue District is probably more nearly a typical industrial area than any of the others, although the quantity of wastes per acre discharging into the sewers is probably greater than is to be expected from the industrial areas of the city as a whole. The conventional curve and other data for the district are shown in Fig. 2.

The effect of the industrial wastes in increasing the per capita rate of flow in this district is clearly shown by comparing the average rate of 363 gals. per day with that obtained in the residential district, where the average quantity of sewage was found to be 80 and 92 gals. per capita per day respectively.

Quantities of Industrial Wastes.—In connection with the studies of the purification of sewage, a careful census of the industrial establishments of the city and of those lying north of the city in Mill Creek Valley has been taken. The quantity of water used in the several industries obtained from the canal, wells and other sources, and the quantity obtained from the municipal water supply, together with the estimated quantities of liquid wastes, were tabulated.

Nearly all the industrial plants are located in Mill Creek Valley and the McLean Avenue Sewer districts. The industrial water consumption in this region amounts to about 17,000,000 gals. per day. Not all the water so used is discharged in the form of wastes. The total amount of these wastes is estimated at 16,000,000 gals. per day, which is equivalent to 5,500 gals. per acre daily, the area under discussion being approximately 2,900 acres.

In view of the fact that nearly all of the plants run but 10 hours per day, the maximum rate of discharge of industrial wastes has been estimated on the assumption that 75 per cent. of these wastes are discharged at a uniform rate during these 10 hours. The corresponding maximum rate of flow is 9,900 gals. per acre daily.

Similar estimates of the quantities of industrial wastes from smaller manufacturing districts tributary to the Ohio River show quantities equivalent to 6,000, 1,100 and 2,350 gals. per acre per day, the corresponding maximum rates of discharge being 10,800, 2,000 and 4,200 gals. per acre per day, respectively.

Giving due weight to the extent and the character of the development of the several districts, it is believed that a fair estimate of the maximum rate of discharge of industrial wastes into the intercepters is 9,000 gals. per acre per day. This quantity is assumed to be in addition to the domestic sewage from the resident population and the ground water.

Ground Water.—The quantity of ground water which reaches the sewers depends on the rainfall, the character of the soil and upon whether the sewers and their connecting drains are well or poorly built. Many of the older sewers were laid without precaution to prevent the infiltration of ground water, which even under the best conditions cannot be entirely avoided. The quantity of ground water thus entering the sewers, as previously explained, varies greatly from time to time and is usually highest after rains in the spring of the year.

It has been assumed, as previously explained, that a great increase in the area of the city will take place during the next 40 years. The estimated density of population over this large area is relatively small, being but eight persons per acre, whereas the density of population in a number of other large cities of this country is found to be from 15 to 25 persons per acre. The small number of persons per acre makes it evident that the number of miles of sewers per square mile of area is likely to be relatively small.

The report of the United States Census Bureau upon Statistics of Cities for 1907 contains data from which the number of miles of sewers per thousand inhabitants in cities having populations of more than 30,000 can be derived. From this information it appears that a well-sewered city of 720,000 persons should have about 900 miles of sewers, and it has therefore been assumed, in estimating the quantity of ground water to be provided for, that there will ultimately be that length of sewers contributing to the intercepters. Numerous measurements and estimates of the infiltration of ground water into sewerage systems indicate that 75,000 gals. per mile of sewer is a reasonable daily maximum. It has therefore been assumed that the total quantity of ground water which will eventually reach the intercepting sewers will be 67,500,000 gals. per day, from an area of 140 square miles, equivalent to 750 gals. per acre per day. This unit has been used in computing the quantity of sewage likely to reach the intercepters from each of the several sewer districts.

Storm Water.—It will be noted that in the foregoing discussion of quantity of sewage there is no allowance for storm water. In other words, when the city shall have attained the degree of development herein estimated as probable in 1950, if the quantities of domestic, commercial and industrial sewage and ground water correspond to the estimates, the intercepting sewers designed to take those volumes of sewage will flow full at the time of maximum sewage flow, and there will be no surplus capacity for storm water at that time.

Even then the flow of sewage would not fill the intercepters except during hours of maximum flow, so that during perhaps half of the day there would be a small surplus capacity. The first, and therefore the foulest, run-off from storms occurring at such times could therefore be taken into the intercepters.

The maximum rate of sewage flow estimated for the present time is but little more than half that to be expected in 1950, and after adding the ground water there would still be available at the present time about one-third the capacity of the intercepter at times of maximum average flow. That is to say, storm water could be received up to a quantity approximately equivalent to one-half the maximum rate of flow of sewage and ground water. Thus the first storm water flowing off from the streets and roofs would be conveyed with the sewage to the point of ultimate disposal.

As the years go on the surplus capacity available for storm water would grow less, until ultimately the maximum sewage and ground water flow would fill the intercepters, as stated above.

At the points where the combined sewers discharge into the intercepters adequate storm water overflows must be provided to convey to the nearest watercourse the excess storm water beyond the quantities which the intercepting sewers may be able to receive. The subject of storm water overflows and sewage flow regulators will be discussed in a subsequent article.

Specific Data on Adopted Designs.—Sections—Two forms of cross-section will be employed on the new intercepters, namely, circular and semi-elliptical. The circular type will be used for sections 5 ft. in diameter and less. On all larger sections the semi-elliptical section will be used. In the larger sewers this latter section has the advantage of economy, since the quantity of concrete and excavation are both somewhat less than for a circular section of the same capacity. This type of section is more satisfactory structurally, also, since the flatter invert is more easily built than a large circular invert, and the reinforcing steel is more easily placed. Typical sections of both types are shown in Fig. 3 and the relations of the several hydraulic elements involved in the calculation of flow in the semi-elliptical section are shown in Fig. 4.

Profiles.—The elevations of the several trunk and branch sewers which must discharge into the intercepter govern its elevation and slope, at least within somewhat narrow limits. The design for the Mill Creek intercepter has been made with the requirement that there shall be a scouring velocity of not less than 3½ ft. per second when the sewer is flowing full, and when the discharge is not retarded by high water at the outlet.

Conditions are complicated in the case of Mill Creek intercepter by the frequent high-water stages of the Ohio River. Whenever the river reaches or passes the 20-ft. stage on the Broadway gauge the effect of back water will begin to be felt in the intercepter, and when the river reaches the 30-ft. stage, if not before, the lower portion of the intercepter will be entirely submerged, and much, if not all, of the sewage will then be discharged through the storm overflows into Mill Creek.

When the velocity of flow is checked by the rise of the river deposition of silt will occur in the intercepter. It is desirable that when the river falls again as high velocities as are reasonably possible be obtained to scour out the accumulated deposits.

The average number of days per year when the Ohio River has been at or above any given elevation indicates that there have been on an average 122 days per year when the flow in the Mill Creek intercepter would be checked, and 53 days per year when it would be almost entirely suppressed in the lower section, these periods corresponding to the 20- and 30-ft. stages of the river, respectively.

The Mill Creek intercepter is 4 ft. in diameter in its smallest section. For this section the slope is 0.0015, and this slope continues until a size of 5 ft. 9 ins. is reached, where it changes to 0.0010. At the 7 ft. 3 in. section the slope again changes to 0.0006 and continues at that rate to the outlet where the size of the section is 8 ft.

The Duck Creek intercepter is below the bed of the creek throughout its course and is therefore low enough to receive the tributary trunk sewers without difficulty. The outlet is well above the level of extreme high water in the river and consequently the intercepter will not be

affected by fluctuations of river stage. This sewer ranges in diameter from 2 to 4 ft. and in slope from 0.0052 to 0.0012.

When built, the Ohio River intercepter will be substantially parallel to the Ohio River to intercept the present and future trunk sewers which would otherwise discharge directly into the river. No direct comparison of the several projects for the Ohio River intercepter is possible, since none of the projects is complete without the inclusion of the corresponding scheme for sewage treatment and a definite plan for sewage treatment will not be adopted for several years to come.

Unit Prices.—In all estimates of cost, except those made in connection with the studies of sewage treatment plants, the following unit prices have been used:

Excavation (including refill, sheeting, pumping) for trench with bottom width of 8 ft. and less, per cu. yd.	$ 1.25
Excavation (including refill, sheeting, pumping) for trench with bottom width more than 8 ft., per cu. yd.	1.00
Plain concrete masonry, per cu. yd.	10.00
Reinforced concrete masonry in sections from 5 ft. 3 ins. to 8 ft. 3 ins. diameter, inclusive, per cu. yd.	15.00
Reinforced concrete masonry in sections greater than 8 ft. 3 ins. diameter, per cu. yd.	14.00
Duck Creek outfall sewer, 45-in. section in tunnel, complete, per lin. ft.	27.00
Mill Creek outfall sewer, 8-ft. section in tunnel, complete, per lin. ft.	55.00
Manholes, per lin. ft.	6.00

ASPHALT PRODUCTION IN TRINIDAD.

The production of asphalt in Trinidad constitutes the chief source of mineral wealth of the colony. At Brighton the company which has the exclusive right to dig for asphalt on Government lands has built a jetty capable of accommodating ocean steamships. It also has extensive works for handling the crude asphalt and refining it. This company has also acquired large petroleum concessions in the neighborhood of the "Pitch Lake" and is now exploiting them on an extensive scale. The quantities of asphalt exported from 1910 to 1912 are given in the Chamber of Commerce Journal as follows:—

	1910. Tons.	1911. Tons.	1912. Tons.
Crude	143,249	149,844	155,908
Pure	15,734	19,283	20,169

The United States was the largest purchaser of Trinidad asphalt in 1912, receiving about 55 per cent. of the total amount exported; whereas the United Kingdom imported only 16 per cent., Germany 13 per cent., and Holland 8 per cent., the remainder going to different countries in small quantities. Mining for manjak was continued in two districts of the colony during the year and 1,530 tons of that mineral valued at £3,060 were exported to the United States and the United Kingdom.

A Boston publication reported recently that the British Columbia Copper Company has but one furnace in blast, indicating operations of no better than 33 per cent. of capacity. It is understood the management will consider closing down the entire plant. In May, there were produced 528,458 pounds of copper, 2,114 ounces of gold and 9,337 ounces of silver.

UNITED STATES' OPPORTUNITY AS BANKER.

CANADIAN municipalities are looking to the United States for funds. With the prevailing conditions in Europe, it is impossible to raise loans in Great Britain. The last municipal flotation overseas was that of South Vancouver early in July. The amount was £223,287 5 per cent. consolidated stock, at 91. In June, the city of Moose Jaw made a private sale in London of $465,000 5 per cent. debentures. This week a bond house of Montreal has offered to market a loan of $7,300,000 for that city in New York. The price is 96.

Despite the attitude of the United States government respecting loans to European governments engaged in warfare, it seems improbable that Washington will frown upon the bankers who undertake to help to finance Canada's peaceful enterprises. In the early part of last century the United States depended on Europe, and especially on Great Britain, for most of the new capital needed for its development. To-day the accumulations of the United States people are greater than those of any other nation. It is true that additional amounts of foreign capital are still invested in the United States, but the amount is insignificant in comparison with the country's own savings. The wealth of the United States is growing, according to Sir George Paish, at the rate of about $7,000,000,000 per annum, whereas the investments of Europe in the country rarely exceed $300,000,000 in a single year.

The annual growth of banking deposits in the United States in normal years is about $1,000,000,000; the issues of new capital by subscription, so far as the amounts are ascertainable, are about $3,000,000,000; and the sums spent on buildings in the leading cities of the country alone reach $1,000,000,000. Allowing for a certain amount of duplication in these totals on the one hand and on the other for the large sums spent in buildings in all the small cities and villages, upon farm improvements, new factories, mines, lumber propositions, additional stock and machinery, etc., the rapidity with which the wealth of the United States is growing will be evident. There is an excellent opportunity for the United States to strengthen financial relations with the Dominion. Canadian banks and bond houses will continue to do their share of the business as in the past, but obviously the temporary loss of Great Britain as a buyer of Canadian securities should benefit the United States.

REINFORCED CONCRETE PONTOON.

A reinforced concrete pontoon has been constructed to the order of the Sydney Harbor Trust by Stone and Siddeley, of Sydney, Melbourne, and Geelong. The pontoon is to be placed in position at the eastern end of Circular Quay for the use of the Lavender bay and Parramatta river ferry services.

The dimensions of the pontoon are: 100 feet in length, 53 feet 3 inches wide at one end, and 67 feet 7 inches at the other; depth, 7 feet 9 inches, with a 32-inch freeboard. The bottom is flat and the sides and ends are sloped to an angle of 70°. Special attention has been given to the design of the steel work with a view to enable the construction to withstand the excessive strains likely to occur should vessels be berthing at each side of the pontoon at the same moment. In the construction of the top and bottom of the pontoon allowance has been made for a live load of 150 tons, which will be distributed between the posts.—Commonwealth Engineer.

Editorial

ENGINEERING ADMINISTRATION.

It is the purpose of a new course to be started this fall at the Massachusetts Institute of Technology to take the middle way and afford to the students practical proportions both of engineering and of administration. The man who graduates from this new course will set out into practical life equipped with the essential things in the training of an engineer and a man of business. His later success will depend, as in all other cases, on his innate capacity and his power of profiting by the experiences of life.

The new course is, apparently, not designed to make bookkeepers, auditors or accountants in any professional sense, but to furnish the fundamentals in these practices to business men holding administrative positions involving financial responsibility. The student will be instructed in the terminology of the accountant, will learn the places of assets, liabilities, good-will, franchises and the balance sheet; the meaning of profit and loss account, the theory and analysis of accounts in general and of depreciation. Cost accounting will be set forth in principle, with standard methods of determining costs not only of material but of processes, labor and machines. Distribution of indirect costs and overhead expenses will be shown, and the value of cost data toward economy together with various of the inventories and wage payment methods. There will be information given the student on the relative value of investments, of different kinds of securities, government, railroad, industrial, public utility, etc., and of different kinds of bonds.

In matters of transportation, it is proposed to introduce studies in handling freight, terminal facilities and warehousing, the making of railway rates and the classification of freight. Export business will naturally bring with it some study of the nature of this business, ocean rates, customs regulations, tonnage duties and port regulations. Port and inland differentials will be discussed, and private car lines and special transit privileges.

In matters of industrial organization, the new course will enter into the study of the kinds of such organization from the individual to the trust or holding company, the differences in corporation laws and the influences determining the choice of state in which to secure the charter. There will be lectures on the internal organization of the corporation, the directors, their duties and liabilities, the rights and responsibilities of the different factors to the corporation and the principles governing elections and meetings. Financing of corporations, dissolution, reorganization, state supervision and taxation will be other items in the study of corporations.

The courses that consider business management will take cognizance of the organization of the establishment. There will then be the management of labor, selection and placing of employees, bonuses, efficiency methods, welfare inducements, and the training of the men.

This is an important step towards preparation for that new kind of engineering, the problems of which are those of organization, administration and finance. There is a world-wide demand for men who are not only capable constructive engineers but men who can co-ordinate and organize the resources of a community or of a nation for the accomplishment of a mighty purpose. It is in this relation that Col. Goethals has been spoken of as the greatest engineer in the world to-day. He is a prototype of the engineer of a few years hence.

PROGRESS IN THE IRON INDUSTRY.

There are two usual routes open to the man who wishes to reach the head of a great industrial corporation; one is, as the shop phrase expresses it, "through the boiler room," and the other through the office. The one who begins at the bottom of the mechanical plant gets of necessity a thorough knowledge of the technical end of the work. He must acquire what is nearly as essential to him, the business knowledge, as best he can and usually in irregular fashion and from persons not experts in teaching. The man who enters the office must, to an extent, work down and will be obliged to learn as best he can something of engineering.

However interesting and picturesque the work of the iron master may be, from the taking of the crude material from its bed in the earth to the turning out of the finished iron and steel, the industry, like the great majority of others, is constantly undergoing great changes. They are not only in the interests of a more uniform and a purer product, but for greater safety of life and a smaller amount of labor. A few details showing the rapidity and cheapness with which some of the work is carried on may interest our readers.

In the Messabe range in the Lake Superior district, the iron ore is loaded by steam shovels carrying from four to six tons each. A twenty-ton car is loaded in five minutes or less. These cars are hauled in trains to the ore docks, from which the steamers, carrying from ten to twelve thousand tons each, are loaded in from two to four hours.

Forty to fifty million tons of ore were brought down from Lake Superior last year and unloaded at the various lake ports by machines, which take from five to seventeen tons per shovelful. The largest machine is able to load a fifty to seventy-ton car in less than five minutes. This ore is carried to blast furnaces in trains, often numbering 100 cars; and some trains carrying over 7,000 tons of ore.

The blast furnaces are of enormous size and production. Most of them exceed 500 tons of pig iron per day. Many of them turn out over 200,000 tons per year.

The steel works are on an enormous scale, twenty-ton Bessemer converters being not uncommon, while open-hearth furnaces, making 100 tons per heat, are quite numerous. No one thinks in these days of building smaller than fifty-ton open-hearth furnaces, except for steel castings. The first open-hearth furnace built in this country, forty-three years ago, had a maximum capacity of five tons. Four to six open-hearth furnaces are charged by one open-hearth charging machine, which is controlled by one man. To do this work in the old-fashioned way, by hand labor, would take from thirty to forty men.

The rolling of the steel shows the same progress in labor saving. The great rail mill at Gary, Ind., if kept supplied with ingots, can easily produce 5,000 tons of finished rails in twenty-four hours. This is more than one month's production of many mills in Europe.

These figures show what has already been done and the magnitude of the business. It has gone far beyond what the most optimistic a few years ago thought possible.

INDUSTRIAL SITUATION IN GERMANY.

MILITARY and naval Germany in its insane war lust is paralyzing industrial Germany. At the conclusion of hostilities, the nation's industry and commerce will have suffered a blow, from which it will take at least a quarter, perhaps a half century, maybe more, to recover. Modern Germany presents two outstanding facts, the great increase of the population since 1871 and the growing dependence of the population upon industrial and mercantile pursuits. Industry and trade in Germany maintain directly a population of about 34¾ millions, or more than half the entire population of the German Empire.

Chief among the causes which have helped to place Germany into the front rank of industrial nations is its possession of valuable mineral wealth and of capital to develop them. It has the largest known reserves of coal of all European countries. Upon that foundation, its iron and steel industries have been built rapidly and efficiently. It has copper, lead, zinc and other minerals in fair quantity and great wealth in its salt mines. It has practically a monopoly of potash, and supplies the world with that product.

The industrial hub of the country is the district which stretches from Dusseldorf on the Rhine land to Hamm in Westphalia, and covers a large part of those provinces. Speaking of that district, the Cologne Gazette prophesied some time ago that before long the district between Duisburg and Hamm would form "one enormous settlement, a single expanse of houses from 45 to 50 miles long and from 15 to 20 miles broad."

While Germany is still lagging behind in shipbuilding—the Clyde yards alone turning out a larger tonnage than all the German yards together—good progress is being made nevertheless. That is in some measure due to the naval policy of Emperor William, which would have been well if confined to peaceful work, but directed partly to the building of a gigantic navy, it likely will prove disastrous in the comparatively near future.

Year by year, Germany has become more independent of other countries in industrial products. Comparing the statistics of 1897 with those of 1911, the value of Germany's imports increased in that period by 49 per cent. and that of the exports by 129 per cent., while the increase of population was 23 per cent. Although the country is still largely agricultural, it is no longer able to feed its population. About one-half of the agricultural land is divided into relatively small holdings, while one-quarter is held by large proprietors.

The railways have been State-owned for a generation. Four years ago the country had about 18 miles of railway to every hundred square miles of surface, a ratio exceeded in Europe only by Belgium, Holland, the United Kingdom and Switzerland, in the order named. In his striking picture of the growth of industrial Germany, Mr. W. H. Dawson, in a notable volume on the subject, states that the railway system of that country and the development of its natural and artificial waterways have helped to build up industry and commerce and economic efficiency each to an equal degree.

Another powerful factor in the industrial life of Germany has been the concentration of capital. For instance, ten industrial concerns and nine financial institutions have aggregate capital of $638,750,000, an average of over $33,000,000. Nearly all these large undertakings, including the Krupp gun and shipbuilding firm, with capital of $45,000,000, and the Deutsche and Dresdner Banks, each with $50,000,000 capital, have grown to their present size as a rule by amalgamation with rival enterprises. The firm of Krupp, in which Emperor William has a substantial financial interest, employs 70,000 persons. Now industrial Germany and its 35,000,000 workers, with the other half of that Empire's population, is thrown into war by Germany's military madmen.

ONTARIO STEEL PRODUCTS' REPORT.

The profit and loss account of the Ontario Steel Products Company, Limited, shows net profits for the year ended June 30th, of $106,437. This amount is after providing for depreciation of properties, reduced market value of securities and the entire cost of organization. Deducting bond interest of $36,000 and preferred dividends of $52,500 there remained a sum of $17,937. The company's fixed assets including real estate plant, power rights and goodwill total $1,785,451. The current assets, amounting to $2,259,689 are divided as follows:—Cash, $3,351.94; bills and accounts receivable, $96,459.33; inventories, $346,107.45; securities (at market price), $26,144; deferred charges to operations, $2,175.

On the other hand the company has current liabilities of $118,913, made up as follows:—Bank overdraft, $14,881.27; bills and accounts payable, $72,907.14; bond interest due July 2nd, 1914, $18,000; preferred dividend payable August 15th, 1914, $13,125. The reserve for depreciation, etc., is $22,838.94.

In discussing the company's report, Mr. W. Wallace Jones, the president, states:—"The company shared in the generally unfavorable conditions which existed during the past 12 months, and consequently all the plants were not run to their full capacity. Furthermore, a disastrous fire at the Gananoque Spring and Axle plant seriously interfered with operations, at a most inconvenient time; and while the direct loss was fully covered by insurance, the disorganized conditions that obtained during rebuilding operations seriously affected profits from these works. This fire, which completely gutted the spring works and damaged the axle works at Gananoque, occurred on October 1st, 1913. Rebuilding operations were commenced on October 15th, the building being completed on December 20th, and manufacturing operations resumed on January 2nd. The new building, which is larger than the one destroyed, is strictly fireproof construction, and the insurance rate has been substantially reduced in consequence.

"During the year large extensions and improvements at the shovel plant have been satisfactorily completed, but owing to trade conditions are not being operated at the present time. In view of the development in the auto spring business, the directors recently purchased the property of the Canadian Malleable Range Company, at Chatham. This property is very conveniently situated, and the price paid was reasonable. The directors also have purchased from the Thousand Islands Railway Company a piece of land which later on will be used for an extension to the shovel plant. The McNee property, adjoining the spring and axle warehouse at Gananoque, has also been purchased at a reasonable price, and will give additional and badly-needed storage capacity for springs and axles. The directors have not deemed it prudent to proceed with the suggested factory at Windsor at the present time.

"During the year the plants have all been put in a state of high efficiency, and several new lines of goods have been put on the market. Contrary to the usual custom, the company has written off all organization expenses this, the first year; and have also set up a substantial reserve for future bad debts."

The company has first mortgage 6 per cent. bonds of $600,000. These are due on July 2nd, 1933. It has authorized capital stock of $1,500,000 of which $750,000 are 7 per cent. cumulative preferred shares and $750,000 ordinary shares. All this is paid up.

On August 15, the Panama canal will be opened to commerce for ships not needing more than 30 feet of water. At present war department officials at Washington are perfecting plans for this opening, though the official opening and ceremony will not take place until March, 1915, when a much greater depth will be available.

ENGINEERS' LIBRARY

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer.

CONTENTS.

BOOK REVIEWS.

Business Administration, Its Models in War, Stagecraft and Science.—By Professor Edw. D. Jones; published by the Engineering Magazine, Co., New York. 275 pp.; size 5½ in. x 7½ in.; cloth. Price, $2.00

The subject of this book is treated in three directions: the administrator as general, the administrator as scientist, and the administrator as diplomat. Professor Jones is not an apostle of any special doctrine or practice of management. He looks at the subject in a prospective state by familiarity with the world's greatest thought and action, and he seeks to find in the life and achievements of great generals, statesmen and scientists fundamental principles applicable to the more limited work of modern industrial leaders. He looks upon administration as a process dealing chiefly with the human factor and the operation of universal laws. He conceives of the administrator as a leader of men, even more than a trustee of properties. He realizes that there has been a deplorable diversion between modern industrial and business conduct and modern ethical and moral ideals, and he seeks to show that by a change of viewpoint they may be brought into reconcilement and harmony. He conceives indeed that the recent and rising activity of interest in industrial management is a symptom of the effort at this reconcilement—a movement like the rise of chivalry which tempted the rugged virtues of the warrior with the gentler characteristics of religion, loyalty and courtesy.

Apart from the book itself a seeker of foremost literature upon the subject at hand might well define from the following brief outline of the author's career his ability and comprehensive grasp of the essentials underlying business administration. Professor Jones was educated at Ohio University and the University of Wisconsin. Later at the universities of Halle and Berlin he enlarged upon the subject of economics. Since 1895 he has been in the University of Michigan, first as instructor in statistics and economics, later as assistant professor in economics and commercial geography, and since 1902 as professor of commerce and industry. In the United States Commission to the Paris Exposition he was an expert in social economy. At the St. Louis Exposition he was a member of the International Congress of Arts and Science. As author of "Economic Crises" and of various monographies on the resources and industries of the United States Professor Jones has become recognized as an authority, and the book now under consideration as the latest publication of the Works Management Library of the Engineering Magazine Company will be received with interest and satisfaction.

It is not a book for those who are seeking a ready-made system, but it is a book which will be unusually interesting and profitable to those who are seeking stimulus and direction for their ideas.

American Machinists' Handbook.—By Fred. H. Colvin, A.S.M.E., and Frank A. Stanley, A.S.M.E.; published by McGraw-Hill Book Company, New York; 673 pp.; fully illustrated; size 4 in. x 6½ in.; bound in leather; price, $3.00 net.

This is the second edition of a very useful reference book of machine shop and drawing room data, methods and definitions. The writers had in mind, in the compilation of the work, the fact that every man engaged in mechanical work of any kind, regardless of his position in the shop or drawing-room, frequently requires information that is seldom remembered and is not usually available when wanted. By their endeavor to supply this information in the most convenient form the authors have rendered a great service to young mechanics as well as to practical men in all branches of machine work. The co-operation which manufacturers and individuals tendered them in its construction is an evidence of the general need which has been recognized for a long time in the mechanical arts.

The second edition is larger than the first edition by 160 pp. It has been very carefully revised and each section has been brought up-to-date to correspond with the changing conditions of shop and drawing-room work. Many of the changes therein are due to the suggestions made by the users of the handbook.

In a review it is somewhat difficult to give a clear idea of the scope of a work of this kind. The following section headings, however, each of them divided into various subsections, which will not be numerated, will be found of value:

Screw Threads; Pipes and Pipe Threads; Twist Drills and Taps; Files; Work Benches; Soldering; Gearing; Milling and Milling Cutters; Turning and Boring; Grinding and Lapping; Screw Machine Tools; Speeds and Feeds; Hunch Press Tools; Broaches and Broaching; Bolts, Nuts and Screws; Calipering and Fittting; Tapers and Dovetails; Shop and Drawing Room Standards; Wire Gauges and Stock Weights; Horsepower Belting and Shafting; Steel and other Metals; Steam Hammers and Drop Forging; Knots, Eye-Bolts, Ropes and Chains.

In addition, there are many general reference and miscellaneous tables and a general outline of shop trigonometry.

The dictionary of shop terms is well illustrated and comprises almost 100 pp. It is one of the most useful, not merely owing to its comprehensiveness but to its connection with, and incorporation in, the handbook itself. The index re-

lates to nearly 2,000 items receiving consideration in the work. It has been very carefully worked out and is a valuable asset to speedy reference, so important in a work of this kind.

Asphalts, Their Sources and Utilizations, 1914 Edition.—By T. Hugh Boorman, C.E.; published by the Wm. T. Comstock Co., New York; 192 pp.; 55 plates; size 7 in. x 10 in.; cloth; price, $2.00.

This new edition contains much additional information, practically all of which deals with the developments in road building during the last five years. Five chapters have been added treating respectively of rock asphalt, maintenance, asphalt macadam roads, coal-laid asphalt roads, bituminous road surfaces, and asphalt blocks for roads. The new edition contains eight new plates, including a series of standard tests for asphalt cements for pavements and roads. The book will be found useful by commissioners of highways and municipal engineers because of its authoritative information and the completeness with which the subject is covered.

An addendum has been published in connection with it and is being sold at 25 cents. The pamphlet has been provided so that those having copies of the former edition may be able to obtain the additional matter without having to purchase a new complete volume.

Practical Calculations for Engineers.—By C. E. Larard and H. A. Golding; published by Chas. Griffin & Co., Limited, Strand, London; 387 pp.; 175 illustrations; 31 tables; size 5½ in. x 7½ in.; cloth. Price, $1.00.

This is the third and considerably revised edition of the authors' work, written primarily for engineering students, apprentices, mechanics, foremen, draughtsmen, and others practically engaged in engineering work. The first edition was published in 1907, and none of the information and calculations is old or out of use.

The general principles which the authors have kept steadily in view in the preparation of this work include modern methods of making rapid calculations by the use of the slide rule; some of the more important engineering problems with which every young engineer should be familiar; graphical methods (illustrated by engineering problems) for the ready interpretation of the results of experiment and other work; and, the importance of making a study of the business side of the profession. The first few chapters are confined to elementary calculations, approvals, approximations, technical and mensuration, and calculation of weights. The work goes on to discuss calculations by common logarithms, mechanical calculating devices and the use and value of squared paper. Section 2, comprising 7 chapters, is devoted entirely to mechanics taking up the principles of work, power and energy, acceleration, momentum and centrifugal force, etc., applying them to practical examples in each case. Section 3 is devoted to steam engineering and its various calculations, while the concluding chapter takes up comparative costs of power production for steam, gas, and oil engines.

For the non-technical mechanical engineer engaged in power production the book will be found of considerable assistance. It is not recommended for those who have had extensive technical training in this work, as there is little new information contained therein that would be of further assistance to them, but the work will be found especially suited to satisfy a long-felt want for a book that goes into the subject of steam engineering in such a way that the man who has little more than an average grounding in the principles of arithmetic can very well understand.

Flight Without Formulae.—By Commandant Duchene of the French Genie, translated into English by John H. Ledeboer, B.A.; published by Longmans, Green & Co., London and New York; 211 pages; 84 illustrations; size 6 in. x 9 in.; cloth. Price, $2.25.

The translator in his preface states: "Formulae and equations are necessary evils; they represent, as it were, the shorthand of the mathematician and the engineer, forming as they do the simplest and most convenient method of impressing certain relations between facts and phenomena which appear complicated when depressed in everyday garb. Nevertheless, it is to be feared that their very appearance is forbidding and strikes terror into the hearts of many readers not possessed of a mathematical turn of mind." The writer goes on to state that it is this prejudice that has deterred many from the study of the principles of the aeroplane, and the book under discussion forms an attempt to cater to this class of reader. When it is stated that there is not a single formulae in the whole extent of the work, those who have refrained from studying the literature of aeronautics owing to the many mathematical computations which almost invariably appear in the books devoted to the work, will be relieved to know that there is now on the market a volume which treats of every one of the principles of flight and of the problems involved in the mechanics of the aeroplane without demanding from the reader the most elementary knowledge of arithmetic.

The book is divided into 10 chapters, the first 5 being on flight in still air, taking up the subjects of speed, power and the power plant. The next 4 chapters discuss stability in still air; viz., longitudinal, lateral and directional stability and turning. Chap. 10 takes up the effect of wind on aeroplanes.

Taken altogether, the book consists of simple discussions on the mechanics of the aeroplane that have been so masterfully handled by the writer as to absorb the attention and interest of the non-mathematical mind.

Metal Statistics, 1914.—By B. E. V. Luty and C. S. J. Trench; published by the American Metal Market Co., New York; 287 pp.; size 3½ in. x 6 in.

This is the 7th annual edition of this work on Metal Statistics, and a great deal of useful information is to be found therein for buyers and sellers, as well as for plant managers and engineers, as the data is remarkably comprehensive in the ferrous and non-ferrous metal fields. The latest edition is considerably larger than previous publications. The editors make acknowledgment to the United States Geological Survey, the New York Metal Exchange, and other authorities whose statistics have been used with respect to metal production, etc., in the United States and other countries.

High Power Gas Engines.—By H. Dubbel, translated from the German and edited and expanded, so as to include British engines and British practice, by F. Weinreb; published by Constable and Co., London; 197 pp.; 423 illustrations and 13 folding plates; size 7¼ in. x 10½ in.; cloth. Price, $4.50 net.

When one encounters a text book with this size of page one is generally inclined to petition for some standardization, long talked-of in the matter of size of text books. In this particular instance, however, the grievance is counteracted by the clearness characteristic of the many illustrations which the book contains. The half-tones are exceptionally clear,

whereas the sectional drawings and diagrams in most cases are, if anything, on the large scale—which reflects again upon the question of size. With this off his mind the reviewer, in turning to the subject-matter of the work finds it a treatment of the theory, principles of operation and the most important constructional features of large 4-cycle and 2-cycle gas engines. As a guide for the student or designing engineer it will be found to contain the same essential and technical details as have been typical of similar works on steam engines in years past. Further, its value to engineers who have not specialized upon large gas engine work is to be emphasized.

The book, or rather the theoretical part of it, deals with the question of efficiency, also compression and mixture ratios, the latter being dealt with under assumption of both constant and variable specific heats. More special attention has been given, however, to the constructional features and conditions governing the design of various engine parts which makes the book, with its clear and carefully drawn illustrations, one of great assistance in design.

Other points that have received attention are the question of cooling and the consideration of large forces acting upon the piston, these points being so important as to have influenced the design of large gas engine parts in a very distinct manner.

In translating the work Mr. Weinreb calls attention to the German text dealing only with large size double-acting gas engines, whereas the growing tendency in Great Britain is the use of the multi-cylinder single-acting type up to, for example, 1,500 b.h.p. For this reason he has included this type in the translation, observing that the troubles formerly experienced with large cylinders seem to have led to the development of the more moderate sizes. The chapter headings throughout the work are as follows: The Cycle of the Gas Engine; Output and Cylinder Dimensions; the Governing of the Four-Cycle Engine; Valve Gear of Four-Cycle Engines; the Two-Cycle Engine; Valve Gears; Ignition; the Cylinders; Valves and their Cooling; Pistons and their Cooling; Piston Rod Couplings; Stuffing Boxes; General Design of Principal Parts; Calculation of the Flywheel Weight; Starting; Piping.

Technical Mechanics, Statics and Dynamics.—By Edw. R. Maurer, Professor of Mechanics in the University of Wisconsin; published by John Wiley & Sons, New York; Canadian selling agents, the Renouf Publishing Co., Montreal; 356 pp.; 529 illustrations; size 6 in. x 9 in.; cloth. Price, $2.50 net.

The first edition of this work was published 10 years ago and it will be remembered that it was received with considerable satisfaction by students of engineering. As stated in the preface of the book, "Although the title might suggest such, it is not comparable to books commonly called 'Theoretical Mechanics,' generally intended for students of mathematics or physics nor to books on applied mechanics, generally including a treatment of strength of materials, hydraulics, etc." In 'Technical Mechanics,' the subjects discussed from the theoretical side have each a direct bearing on engineering problems and the applications illustrate principles of mechanics with a view to training students in the use of such principles rather than in the furnishing of direct information.

The present edition is a practically rewritten book and contains considerably more material than the previous work, including a new collection of problems. The chapter on attraction and stress which appeared in previous editions has been removed so that the new arrangement is as follows: Chap. 1, Composition and Resolution of Forces; Chap. 2, Forces and Equilibrium; Chap. 3, Simple Constructions; Chap. 4, Friction; Chap. 5, Center of Gravity; Chap. 6, Suspended Cables, Wires, Chains, etc.; Chap. 7, Rectilinear Motion; Chap. 8, Curvilinear Motions; Chap. 9, Translation and Rotation; Chap. 10, Work, Energy and Power; Chap. 11, Momentum and Impulse; Chap. 12, Two-dimensional (plane) Motion; Chap. 13, Three-dimensional (solid) Motion. The book contains two appendices, the first of which entitled "Theory and Dimensions of Units" is substantially the same as Appendix "A" of the first and second editions of the work. Appendix "B" devoted to moment of inertia and radius of gyration of plane areas, has been added, as writers on strength of materials usually refer to works on mechanics for a discussion of this subject. The volume concludes with 193 problems illustrated and arranged to follow consecutively the general method of analysis adopted throughout the book. With each problem has been given a number, in parenthesis, which refers to the article pertaining to that problem. The work as a whole is a technical discussion written specially for engineering students, the author himself a professor of mechanics in a well-recognized university has made evident throughout the work his authoritative conception of the academic requirements necessary for the modern method of training in an engineering school. It will be found to reiterate the satisfaction with which the previous editions have been accepted and its thorough revision will make it of extreme value as an authority on the subject.

Mechanical Movements, Devices and Appliances.—By Gardner H. Hiscox, M.E.; published by the Norman W. Henley Publishing Co., New York City; 409 pp.; fully illustrated; size 6 in. x 9 in.; cloth. Price, $2.50.

This book is the 14th edition, considerably enlarged over previous editions, of a work describing mechanical movements and devices used in constructive and operative machinery and in the mechanical arts. Practically speaking, it is a sort of mechanical dictionary, illustrated by over 1,800 engravings, and commencing with a rudimentary description of the early non-mechanical powers and detailing the various motions, appliances and inventions used in the mechanical arts up to the present time. The latest edition contains about 160 new and added mechanical movements and devices and includes a chapter on straight line movements, which makes the work a useful book of reference for those engaged in mechanical studies and pursuits, particularly for those who have to do with inventions and machine design.

The section headings are as follows: Mechanical Powers; Transmission of Power; Measurement of Power; Steam Power; Steam Appliances; Motive Power; Hydraulic Power Devices; Air Power Appliances; Electric Power and Construction; Navigation and Roads; Gearing; Motion and Devices Controlling Motion; Horological Mining; Mill and Factory Appliances; Construction and Devices; Drafting Devices and Miscellaneous Devices.

Scales for Ascertaining the Dimensions of Pipes, Drains and Sewers.—By C. E. Housden, Sanitary Engineer to the Government of Burma, Eastern Bengal and Assam. Published by Longmans, Green and Co., London, England; 16 pp.; 5 plates; size 5 in x 7 in.; price, 40 cents.

This small book contains a number of scales for ascertaining the dimensions to the nearest inch of pipes or half-pipes and of any design of drain or sewer in which a semicircle or circle can be inscribed, adopting at will any discharge

co-efficient. The scales are taken from the author's book entitled "Water Supply and Drainage, Systematized and Simplified," in which work their construction has been fully explained. The book contains two very useful tables, Table 1, giving the value of the water area in square feet, the wetted perimeter, the hydraulic mean depth, and the discharge reduction co-efficient for different slopes of masonry drains and for drains in earth. Table 2 is similarly a useful table to be used in connection with the plates or diagrams for ascertaining pipe dimensions. Doubtless these scales will be found of considerable assistance to engineers of sewerage works.

PUBLICATIONS RECEIVED.

Coal Mine Fatalities in the United States, June, 1914.—The monthly statement of the Bureau of Mines, Department of the Interior, Washington, giving the statistics for coal mine fatalities in June, and also revised figures for preceding months. Compiled by Albert H. Fay.

Pollution of Boundary Waters—A 4-page leaflet, being a resume of testimony of consulting sanitary engineers in the matter of the pollution of boundary waters between the United States and Canada. Issued by the International Joint Commission, and published by the Government Printing Office, Washington.

Report of the City Waste Commission of the City of Chicago.—A 69-page report of the Commission created by the order of the Chicago City Council to make a comprehensive study of the subject of the collection, delivery, and disposal of garbage and waste. T. McLean, Jasper, M.Sc., Assistant Secretary, Engineer of the Commission, publishes the report.

Waste of Oil and Gas in the Mid-Continent Fields, United States.—A 57-page report, compiled by Raymond S. Blatchley, and issued by the Bureau of Mines, Department of the Interior, Washington, showing the past and existing waste of gas and oil in states including Kansas, Oklahoma and Northern Texas, and attempting to show the importance of conserving these natural resources.

Forest Insect Condition in British Columbia.—Bulletin No. 17 of the Second Series. An illustrated 41-page booklet, giving the result of a preliminary survey made by J. M Swain, Assistant Entomologist for forest insects, the object being to further the effort of conserving the timber resources of British Columbia. Issued by the Division of Entomology, Department of Agriculture, Ottawa.

Report of the Sewage Disposal Commission, 1913, Fitchburg, Mass.—Being the seventh semi-annual report which has been published since the establishment of the Sewage Disposal Commission at Fitchburg in 1910, and presenting an account of the doings, receipts, and expenditures of that body on the improved sewer system of the municipality for the six months ending December 31, 1913. The report contains illustrations and maps, and consists of 48 pp.

Report of Mining Operations in the Province of Quebec, 1913.—Issued under the authority of the Mines Branch, Department of Colonization, Mines and Fisheries, Province of Quebec; and submitted by Theo. C. Denis, Superintendent of Mines, as the annual report of the Mines Branch on the mining operations, mineral production, and geological field work of the Province of Quebec during the calendar year 1913. This report supersedes a preliminary statement which was published on February 23, 1914, was mainly statistical, and was submitted subject to revision. This report is 163 pp. in length, including a few illustrations.

Annual Report of the Topographical Surveys Branch, 1912-13, Department of the Interior, Ottawa.—This report consists of 226 pp., and, as a preliminary, gives the report of the Surveyor-General of Dominion Lands. The bulk of the work consists of 52 appendices, 10 of which are devoted to schedules and statements compiled by the Topographical Surveys Branch, the remaining 42 being reports and abstracts of reports from various surveyors. The book includes also 17 maps and profiles, and a fair amount of illustrations. The surveys made in Northern Manitoba and the Peace River district may be considered most interesting; since these were made on a larger scale than previously. Progress, however, is shown in all provinces of the Dominion.

Second Report of the Quebec Streams Commission.—Vol. 1, a 121-page booklet which has been translated from the French and contains a statement of the studies of a general nature which were carried on by the Quebec Streams Commission, Montreal, during the course of the year 1913, exclusive of the work accomplished during that period in connection with the proposed St. Maurice River water storage; Vol. 2, of 100 pages, being a supplement to the year's report, or the work done under the direction of the Commission in connection with the project for regulating the flow of the St. Maurice River, together with the plans and specifications of the works to be erected; and an appendix, under separate cover, containing maps made by the Commission.

Annual Report of the Minister of Mines, 1913.—459 pp., 7½ in. x 10½ in., containing illustrations and maps, and being an account of mining operations for gold, coal, etc., in the Province of British Columbia, and printed by authority of the Provincial Legislative Assembly. The work is compiled by William Fleet Robertson, Provincial Mineralogist, and gives the total mineral output of the province up to the year ending December 31st, 1913, showing in considerable detail the actual mineral production of the last year as based on smelter or mill returns, and making a summary of the production of each of the last four years. It thus illustrates by comparison the progress made in productive mining during this period.

Wood-Using Industries of the Maritime Provinces, Bulletin No. 44.—An illustrated 100-page bulletin compiled from reports received from over six hundred manufacturers in the Maritime Provinces using wood as a raw material. It reports on the quantity, value, and source of supply of the different kinds of wood used by the industries of the provinces; includes detailed descriptions of the different classes of industries and of the properties of the woods; takes up the ten kinds of wood used in greatest quantity and shows the extent to which the industries respectively use these; and appends a classified directory of the manufacturers who supplied the data used in the compilation. The report is the work of R. G. Lewis, B.Sc.F., assisted by W. Guy H. Royce, and is published under the Forestry Branch, Department of the Interior, Canada.

Evidence Given Before the Select Standing Committee on Agriculture and Colonization, Third Session, Twelfth Parliament, 1914.—This is the first of a series of four reports presented by the committee, and is compiled of the evidence of Mr. Wilson, M.P. for Wentworth, and Messrs. F. F. Espenchied and J. W. Purcell, of the Ontario Hydro-Electric Power Commission, taken by the Committee during the current session of parliament, and dealing with hydro-electric power as applicable to the farm; the evidence of Mr. John Bright, Live Stock Commissioner of the Department of Agriculture, on the production and marketing of live stock; the evidence of Mr. J. B. Spencer, of the Distributions Branch of the Department of Agriculture, on the methods of distribution in vogue

in that Branch; and the evidence of Miss Wileman on the establishment of a free labor bureau system in Canada. The book includes maps and a fine list of illustrations.

Report of the Building and Ornamental Stones of Canada, Vol. II.—This report, which is published by Wm. A. Parks, B.A., Ph.D., under the Mines Branch, Department of Mines, Ottawa, forms the third part of the Monograph on the Building and Ornamental Stones of Canada, of which Part I. constitutes a general introduction and Part II. deals with the stones of the Province of Ontario. The work consists of 264 pages, 6½ x 9½ inches, including appendices and illustrations. The field work upon which the report is based was done during the summer of 1911, when, within a period of two and a half months, sixty quarries were visited, as well as a considerable number of abandoned quarries and prospects. But, though this report is by no means confined to quarries in actual operation, it does not pretend to include every opening that has been made for the production of building stone. The object was to represent by a typical example every important district and to give due consideration to every stone commercially available at the present time. The sketch maps accompanying the report were prepared by Mr. R. R. Rose, and are designed to show the general geology of the region, and more particularly to point out the location of the important quarries; only a few quarries not in actual operation being indicated, and no attempt being made to show the numerous small pits that have been opened for the obtaining of limestone for flux or for lime-burning.

CATALOGUES RECEIVED.

Gurley Automatic Water Stage Registers.—A 31-pp. pamphlet showing and illustrating the use of water stage registers manufactured by W. & L. E. Gurley, Troy, N.Y.

Railway Motor Gears and Pinions, Bulletin "A" 4199.—A small booklet showing the various grades of gears and pinions handled by the Canadian General Electric Co., Limited, Toronto.

Evidence of Toncan Metal.—A small booklet of illustrations issued with a view to giving visual evidence of Toncan Metal in actual use. Published by the Stark Rolling Mill Co., Canton, Ohio.

Clyde Land-Clearing Machinery.—An attractive 16-page catalogue, finely illustrated to show the logging, hoisting, excavating, stump-pulling, and land-clearing machinery manufactured by the Clyde Iron Works, Duluth, Minn.

Industrial Buildings, Limited, designing and supervising engineers and contractors of building construction and equipment, Toronto, has issued a small booklet showing the company's method of construction in modern industrial buildings.

The Cement-Gun, the Apparatus, Process and Product.—A well illustrated 106-pp. booklet, being a compilation of the record of the development of the cement-gun since its inception as a commercial enterprise three years ago. Edited by Arthur E. Lee, and published by the Cement-Gun Co., Inc., New York, N.Y.

The "Badger" Catalog, No. 13.—A 32-page booklet issued by the Canadian Allis-Chalmers, Limited, and descriptive of badger engines for gas, gasoline, or kerosene, built by the Christensen Engineering Co., Milwaukee, Wis., and dealing with those which are specially adapted for the operation of grain elevators and grist mills.

Drinking Water Systems.—A 45-pp. booklet, illustrated, to show the value of Nonpareil Cork Covering for drinking water systems in mills, factories, hotels, office buildings, hospitals, public buildings, etc. Issued by the Armstrong Cork and Insulation Co., Pittsburgh, Pa., for which firm the Kent Co., Limited, 705 Lumsden Bldg., Toronto, are the Canadian distributers.

Ice-Handling Equipment.—A 64-page booklet, fully illustrated, and containing general information for purchasers of ice elevators, conveyors, lowering machines, ice tools, and icing station equipment, manufactured by the Gifford-Wood Co., with New England headquarters at Nos. 51-52 North Market St., Boston, Mass., and western headquarters at No. 103 North Jefferson St., Chicago, Ill.

Power, Its Economical Distribution.—A well finished and well illustrated booklet issued by the British Aluminium Co., Limited, 109 Queen Victoria St., E.C., London, England, being No. 108 publication on aluminium insulated cables. The object is to show the economy of the product, the easy solution of working and jointing problems in the use of the metal, and the low scrap value of these cables.

General Catalogue of the Dominion Equipment & Supply Co., Limited, Winnipeg.—A 414-page book, illustrated and indexed, describing in a brief and comprehensive manner the various lines of machinery, equipment, and general supplies manufactured and handled for the use of steam and electric railroad contractors, general contractors, bridge builders and structural steel erectors, coal mines, stone quarries, blacksmiths, factories, mills, municipalities, electric light plants, waterworks plants, etc., etc. The descriptions are carefully prepared and cover the essential points in representing the goods clearly and concisely. The lists and tables are the latest up to the time of going to press. The catalogue is issued for the year 1914.

BREAKING UP PAVEMENT BETWEEN CAR TRACKS.

An unusual and efficient method of breaking up old block pavement between the rails of a street railway track in preparation for replacing the track has been devised and is being used in Cleveland. To a car with a heavy steel framework and wooden sides about 2 feet high is attached a plow consisting of a heavy steel casting of suitable shape for lifting the paving blocks, and at the same time cutting the tie rods which hold the two rails of the track together. A counterweight is placed in the car to hold the plow in the desired position when the car is pulled along. The plow car with its counterweight weighs about 11 tons.

The plow is pulled by a service motor car equipped with four Westinghouse motors. This car is of steel, of the hopper type, behind the motorman's cab and the motor mechanism, and is loaded with blocks, then weighing about 50 tons. Three men and the crew of the motor car are all that are necessary to operate the plow.

With this apparatus it has been found that 1,300 square feet of pavement can be removed in one minute. On one occasion the pavement in a stretch of track 2,600 feet long was removed in 35 minutes. The only difficulties experienced have been breakages of the cable, which have not occurred often. The plow is used only one or twice a week, since an hour's work with it gives enough track to work on for about ten days. The plow has been in use for several months. It is described in a recent number of the Electric Railway Journal by its designer, Charles H. Clark, engineer of maintenance of way for the Cleveland electric railways.

On August 16 the Canal zone celebrated the opening of the Panama Canal. The official celebration of international significance has been set for next spring. The steamship Ancon, owned by the United States War Department, and leased to the Panama Railroad for service in the New York-Colon trade, was chosen as the first big boat to be put through, signalizing the opening of the canal to all ships up to 10,000 tons register.

Coast to Coast

Toronto, Ont. A passenger train service was opened by the C.N.R. between Toronto and Ottawa on August 18.

Montreal, Que.—The repairs to the water supply conduit were completed last week, and the city is being served again with its regular water supply.

Grand Falls, N.B.—On August 13th, the new bridge which has been constructed just below the Grand Falls and has just been completed, was formally opened for traffic.

Moose Jaw, Sask.—The new armory which has been erected at Moose Jaw at a cost of $110,000 has been formally taken over by the department of militia of the Dominion Government.

Ottawa, Ont.—A recent communication from Ottawa says that in that city there will be constructed this year about $600,000 worth of pavements, which is twice the amount that was undertaken last year.

Toronto, Ont.—It is anticipated that a definite compromise will be reached very shortly between the civic and provincial hydro-electric commissions relative to the much discussed question of hydro-electric power rates.

Sarnia, Ont.—Under the supervision of Town Engineer McLean, of Sarnia, a new concrete bridge for foot passengers has been completed across the canal in Bayview Park. The structure is of a very permanent as well as artistic design.

Montreal, Que.—The question of proceeding with public works being undertaken by the federal and provincial governments and by the municipal administration of Montreal, is being studied very carefully by the various labor organizations and associations of the city.

Winnipeg, Man.—The city council of Winnipeg has passed a report and supplementary report of the board of control containing accounts to the number of 455, totalling $158,007.98. Also accounts of the hydro-electric department were passed, numbering 59 and totalling $24,971.91.

Hamilton, Ont.—Steel contracts have been awarded and satisfactory bulk tenders have been secured for the erection of the Royal Connaught hotel in the city of Hamilton. The cost is now placed at about $1,000,000, or about $100,000 more than the early estimates. The commencement of the erection of the building will soon be in progress.

Brantford, Ont.—The raising of Lorne Bridge at Brantford by Mr. Reuben Rogers, contractor of Guelph, is proceeding at the rate of two feet per day; and the work is expected to be finished within the next 10 days. The new White Bridge, which has been constructed on the Hamilton road in the township, has been completed and publicly opened for traffic.

Valcartier, Que.—Mr. William Perry, hydraulic engineer of Montreal, is engaged upon the installation of the pumping plant for supplying the military camp at Valcartier, consisting of duplicate electric-driven pumps, having a capacity of 80,000 gallons per hour under a pressure of 80 pounds per square inch. Pipes are being laid over the ground for a general water supply.

Trenton, N.S.—A water system is in process of construction at Trenton, N.S., at a total cost of about $20,000. A reservoir has been almost completed about 250 feet above the business part of the town; and at present, a deep well Deane pump with 20 h.p. motor is being installed beside the reservoir by the Messrs. Doane Engineering Co., of Halifax. This same firm has just secured the contract for extensions to water pipe in the town.

Victoria, B.C.—Mr. J. F. Whitson, Commissioner of Roads for Northern Ontario, has finished his program of work for this year, which has entailed an expenditure of $850,000 out of the $5,000,000 appropriation voted two sessions ago by the provincial government. The remainder of the $1,000,000 which was to be expended this season is still proceeding under contract and is chiefly clearing.

Edmonton, Alta.—Representatives of the Edmonton Industrial Association have waited on the city commissioners regarding the contract between the city and the association relative to the gas well at Viking. The association is advocating that the city take over the drilling operations, pay the amount called for under the contract between the association and the drilling company and reimburse the citizens who have been financing the scheme.

Victoria, B.C.—Difficulty in establishing a satisfactory foundation for the Hudson's Bay Company's new block at Victoria is being experienced. The architects have insisted that, before the superstructure is started, a footing must be made entirely on solid rock. Up to date, bed-rock on the north-east corner of the site had not been obtained; though, in one case, excavation had been carried to a depth of 60 feet, and nothing beyond blue clay reached. The work is in the hands of the B.C. Construction and Engineering Company, general contractors for the building.

Point St. Charles, Que.—Work has been progressing very rapidly at Point St. Charles upon the excavation of a cave-in which occurred recently to the sewer in Mill Street. Four emergency pumps, each with a capacity of 2,000 gallons per minute, had to be erected to remove the stagnant sewage from the streets affected by the damaged sewer; and a steam shovel was also employed to hasten the repair work necessary. The result of the break has been to draw attention to the necessity for widening the Wellington Street subway, which was made entirely impassable by the overflowing sewage.

Victoria, B.C.—The province of British Columbia is to benefit by the construction of a fair share of public buildings, should the Dominion Public Works Department proceed with the awarding of contracts for those for which tenders have already been called and received. The projects in view comprise post offices for Merritt, Courtenay, Ashcroft, and Prince Rupert; a detention house and examination warehouse at Union Bay; and a third-class immigration shed at Prince Rupert. In the event of there being no alteration in the original programme, it is expected that this work will be inaugurated without loss of time.

Quebec, Que.—From across the ocean, built by Cammell and Laird at their Birkenhead works, has come the "Leonard," a costly car ferry and ice-breaker for the N.T.R. Company. It is to be used to connect the Quebec and Levis ends of the line until the Quebec bridge is completed. The naval architecture of the ferry is interesting. Her tidal and promenade decks are built a considerable distance above her main deck. Her speed is about 15 knots an hour, and she has four funnels. Her tidal deck has three lines of tracks, each 270 feet in length. She is propelled by two sets of triple expansion engines, and she has a length of 326 feet, a beam of 65 feet and a draft of about 15 feet.

Winnipeg, Man.—The board of Greater Winnipeg Water District passed recently estimates amounting to $190,815. Included in these were $61,000 to the Algoma Steel Corporation for steel rails; $45,000 to the Northern Construction Co., and $48,000 for ties to O'Brien and McDougall. The board also received reports on constructive work and supplies, showing as the most important progress which has been made: the completion of clearing the right-of-way, involving 2,583 acres; the completion of more than one-third of the work in connec-

tion with the Falcon River diversion dyke; and the completion of boring operations for water at Deacon, which has resulted in the obtaining of a supply of 40,000 gallons per day.

Wallaceburg, Ont.—A progress report on the work being done by the Thrasher Company of Toledo states that all the work at the pumping station for the new waterworks system has been completed, and the construction of the station has been commenced. While dredging for the pipe line to be laid across South Wallaceburg, about 25 spiles and many old trees had to be dug out of the sewer bank, and divers had to be employed frequently. The work in the town is somewhat behind due to trouble being experienced by the contractors on account of sand cave-ins. On Wellington Street, where the pipe has to be laid at a depth of 20 feet to pass under the river, the entire sewer is being planked to the full depth. The lack of pipe also is delaying outside construction.

PERSONAL.

CHAS. J. GIBSON, formerly of Haileybury, has been appointed by the town council of Bowmanville to the office of Town Engineer.

H. C. COX, president of the Canada Life Assurance Company, has been elected a director of the Canadian General Electric Company in succession to his brother, E. W. Cox, recently deceased.

R. W. McCONNELL, a member of the staff of the Geological Survey, Dominion Government, Ottawa, has been appointed Acting Deputy Minister of Mines, following the resignation of R. W. Brock, as Deputy Minister of Mines.

DR. C. W. DRYSDALE, of the Geological Survey ot Canada, who has engaged at the government's camp at Rossland, B.C., has completed his work there and is now at Ymir, in Nelson mining division of West Kootenay, B.C., making a study of the ore deposits at that camp.

ROBERT ROSE, of 295 Jarvis Street, Toronto, and also of Victoria, B.C., an engineer who has gained much knowledge of the Orient and its languages, as well as much experience among British and Canadian manufacturers of power machinery, is perfecting arrangements with several large engineering firms in Eastern Canada to represent them in Shanghai, China. It is understood that in that country there is an ever-increasing demand for transport and power machinery, and Mr. Rose, with his qualifications, will doubtless be successful in the undertaking of opening this new export business.

JOS. BILLINGHAM has been appointed to the position of Superintendent of Motive Power for the Grand Trunk Pacific Railway Company, and succeeds G. W. Robb, who resigned recently from the office. Mr. Billingham is a native of England, and his first position of importance was with the London and Northwestern Railway. Subsequent to his connection with this railway company, he has been master mechanic for the Burlington and Ohio Railroad, European manager for the Galena Signal Oil Company, and, directly previous to his new office, superintendent of works for the American Locomotive Company at Schenectady, N.Y. Mr. Billingham's new headquarters will be at Transcona, Man.

JOHN S. BATES has been appointed to succeed A. G. McINTYRE, resigned, as superintendent of the Dominion Forest Products Laboratories in connection with the McGill University. Mr. McIntyre is now in charge of a new paper mill at Bathurst, N.B. Mr. Bates was born at Woodstock, Ont., and is a graduate of Acadia University in arts and science. After leaving Acadia, he went to Columbia University, New York, and graduated in chemical engineering, specializing in pulp and paper. He made a study of the utilization of Southern pine waste while at Columbia, and since the conclusion of a brilliant course there has had practical experience with the Union Bag and Paper Co., of New York, and Arthur D. L. Little, Inc., chemists, of Boston. Mr. Bates has already entered upon his new duties.

THOMAS TURNBULL has received the appointment of assistant chief engineer for the Canadian Northern Railway Company, with offices at Winnipeg, Man. Mr. Turnbull began his engineering experience in 1881 as transitman on location for the Canadian Pacific Railway, and later became resident engineer on construction on that road. In 1889-91 he was employed by the Newfoundland government as engineer in charge of a location party and construction work on the Halls Bay Railway. From 1891 to 1897 he was assistant engineer of maintenance and construction on the Western Division of the Canadian Pacific. For three years following he was chief engineer of the Canadian Northern Railway lines west of Winnipeg. In 1900 he was engaged in contract bridge work on the Canadian Pacific, and during the following year on reconnaissance work for the Dominion Government. From 1902 to 1904 Mr. Turnbull was again in the employ of the Dominion Government as inspector of surveys. From 1904 to 1910 he occupied the position which he now holds, that of assistant chief engineer for the Canadian Northern Railway. In 1910 he went to the Hudson Bay Railway as assistant chief engineer, and remained in that position until 1912, since when he has been chief engineer of the Edmonton-Dunvegan Railway.

REGINALD W. BROCK has resigned the office of Director of the Geological Survey and Deputy Minister of Mines, and has accepted an appointment as head of the Applied Science Department of the new University of British Columbia. Mr. Brock was a student of the University of Toronto from 1891-92. During the summers of these years, Mr. Brock acted as field assistant to the Geological Survey. On the organization of the School of Mining in Kingston, he enrolled as a student in Queen's University, graduating in 1895. The summer of 1895 was spent at the University of Heidelberg; and the subsequent autumn, Mr. Brock was given temporary charge of the Department of Mineralogy at Queen's University, from which he resigned to become a permanent member of the staff of the Geological Survey of Canada, chiefly in British Columbia. After five years in the office of this department, another year was devoted to study again at the University of Heidelberg; following which, Mr. Brock became Professor of Geology in the School of Mining at Queen's University. Since that time, also, he has maintained his connection with the Geological Survey branch, spending the field seasons in British Columbia, where his most recent work has been the detailed examination of the Rossland mineral area, and his valuable report on several mines of that district made about three years ago at the requests of the different companies.

OBITUARY.

The death occurred recently of William R. Sinclair, railroad and general contractor, at his home, 1412 Portage Avenue, Winnipeg. The deceased was 67 years of age, was a native of Scotland, and has been a resident in Manitoba for 50 years. Mr. Sinclair was one of the promoters of the South Eastern, now a part of the Canadian Northern Railway, being one of the first contractors engaged on that work.

BERTRAND G. DYE met death by drowning on August 23rd at Balmy Beach, Toronto. Mr. Dye was an engineer, occupying the office of superintendent with the firm of Tate Electrics, Limited, and previously was connected with the work upon the Toronto filtration plant. The deceased was a native of South Norwood, Surrey, Eng., and a graduate of King's College, London.

SECOND INTERNATIONAL WATER-POWER CONGRESS.

The second International Water-Power Congress will be held during September 7 to 10 at Lyons, France, under the auspices of the Ministers of Public Roads and Agriculture. After the convention trips will be conducted to important hydro-electric developments in the Alps. There will be three sections, one on legislation, another on finance and a third on technical questions. The first section has seven questions to deal with—(1) summary of water power legislation in Austria, Canada, England, Germany, Italy, Norway, Russia, Spain, Sweden, Switzerland and the United States, (2) water rights on unnavigable streams where no logging is prevailing, (3) laws for water-power plants using water on public domain, (4) laws for water-power plants using water in unnavigable streams, (5) international rules for the utilization of rivers belonging to two countries, (6) export and import of electrical energy, and (7) laws for regulation of rivers and utilization of water powers in government forest districts. The second section will discuss the following topics: (1) Economical results connected with the management of the River Rhone, (2) reservoirs for river regulation, (3) levees and their influence on industries using the energy of water, (4) the influence of the government on the economical development of water power, (5) capitalization of water powers developed by private interests and those developed by governments or municipalities, (6) local profits due to utilization of power, (7) undertakings for regulating river discharges, (8) water power and the metallurgical industries, (9) water power and the electrification of railroads, and (10) water power and agriculture. The section for technical questions will deal with—(1) hydro-electric plants bypassing rivers, their dams and other structures, (2) protection of rivers, (3) measurement of discharges, (4) surge tanks, (5) hydro-electric laboratories, (6) metal pressure conduits, (7) pressure conduits of reinforced concrete, (8) turbines, (9) backwater from dams, and (10) transmission of energy.

AMERICAN HIGHWAY ASSOCIATION CONGRESS.

Governor Slaton, of Georgia, has requested the Governors of all the other states to act favorably upon the invitation of Austin B. Fletcher, president of the Fourth American Road Congress, to name official delegates to the Congress, to be held at Atlanta, Ga., November 9 to 13, 1914. Already forty-seven organizations have signed the official call. The parent organizations are the American Highway Association and the American Automobile Association. Co-operating prominently through the holding of special sessions, the American Bar Association, the American Bankers' Association, and the National Civil Service Reform League will cast the weight of their prestige in behalf of the Congress. Hundreds of county boards will be represented by their chairmen or county engineers to profit by the discussions of the most eminent road builders of America; to study the eminently instructive government exhibit, which includes designs of every known type of road; and to compare critically the machinery, materials and engineering instrument exhibits from hundreds of manufacturers. So closely are city, street and county road problems now related that an exceptionally large number of cities will this year delegate their street superintendents and city engineers, or their mayors, to the Congress.

Logan Waller Page, Director of the United States Office of Public Roads, will preside at one or more sessions of the Congress. Austin B. Fletcher, State Highway Engineer, of California, will open the sessions as President, and will be assisted by the Vice-Presidents, E. M. Bigelow, State Highway Commissioner of Pennsylvania; A. N. Johnson, formerly State Engineer of Illinois; W. E. Atkinson, State Highway Engineer of Louisiana; and Charles A. Magrath, Chairman, Ontario, Canada Highway Commission.

An elaborate series of social entertainments has been planned by Atlanta, which will include receptions, banquets, and excursions. At least six thousand delegates are expected, or two thousand more than attended the 1913 meeting in Detroit. And co-operation of a most thorough character is assumed by the railroads, as they have already granted a round trip lower than has been granted for years to national meetings.

SIXTEENTH ONTARIO MUNICIPAL ASSOCIATION MEETING.

On September 2nd and 3rd will be held in the City Hall, Toronto, meetings of the Ontario Municipal Association, at which will be discussed the following questions, introduced by the following officials of various municipalities: "A Government Minister and Department of Municipal Affairs," Mr. S. H. Kent, City Clerk, Hamilton; "Municipal Accounts and Audits," Mr. A. K. Bunnell, City Treasurer, Brantford; "Settlement of Administration of Justice Accounts," Mr. N Vermilyea, Reeve of Thurlow; "The Relation of a University Education to the Performance of Municipal Duties," Prof. James Mavor, Toronto University; "The Cost of Roads," Mr. W. A. McLean, Chief Engineer, Government Highways Department; "County Municipal Associations," Mr. K. W. McKay, County Clerk, Elgin; "Purification and Protection of Water Supplies," Dr. J. W. McCullough, Secretary of Provincial Board of Health; "Railway Taxation for Municipal Purposes," Mr. W. Johnson, City Solicitor, Toronto.

An address of welcome will be delivered by Mayor H. C. Hocken, of Toronto; and an address upon the present position of municipal affairs will be delivered by the President, Mr. J. G. Richter, of London.

Copies of the programme of this, the sixteenth annual meeting of the association may be had from F. S. Spence, City Hall, Toronto.

COMING MEETINGS.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Secretary, Will P. Blair, 832 B. of L.E. Building, Cleveland, Ohio. Eleventh annual convention and paving conference, Buffalo, N.Y., September 9th, 10th, 11th, 1914.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown. Indianapolis, Ind., Secretary.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.—11th Annual Convention; 5th American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau St., New York, N.Y.

Volume 27. Toronto, September 3, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

NEW GOVERNMENT DRY DOCK AT LAUZON, QUE.

DETAILS OF DESIGN, INCLUDING CAISSON STOPS, APPROACH, AND PUMPING EQUIPMENT, NOW UNDER CONSTRUCTION FOR THE DEPARTMENT OF PUBLIC WORKS.

THE new dry dock which the Department of Public Works of the Dominion Government has under construction at the village of Lauzon, two miles east of Levis, on the St. Lawrence River, opposite Quebec, will possess many features that will place it among the foremost of such structures. The proposed dry dock is to supplant one already in service at this point. The relative locations of the old and contemplated structures may be noted in Fig. 1, which shows also the general layout of the later development, including the approach slip to be built in conjunction with it.

The work has been under way since last season. The contract for the construction of the dock was let in July, 1913, to the firm of Messrs. M. P. and J. T. Davis, the contract price being $2,721,116. On October 24, 1913, Premier Borden dedicated the work. Since that time the contractors have been pursuing the excavation work for the dry dock proper. This excavation, as will be noted from Fig. 2, is almost entirely in rock. Very little earth removal is required and this applies also to the amount of dredging necessary.

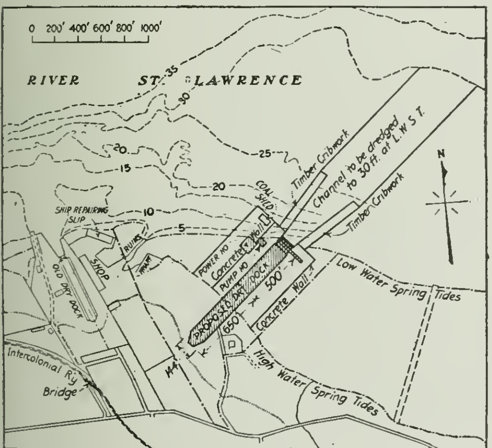


Fig. 1.—Location of the New and Old Government Dry Docks at Lauzon, Quebec.

The dock will be 1,150 ft. in length from headwall to caisson stop. The width of the entrance is to be 120 ft., while the depth on the sill at ordinary high-water spring tide will be 40 ft. The dock will be divided into two parts, as shown in Fig. 3, general plan, the object of which is to be able to use the mid-caisson stop for smaller vessels. A steel rolling caisson, details of which are shown in Fig. 5, will be used to close the outer entrance, while a steel floating caisson, plan and sections of which are shown in Fig. 6, will be used to close the inner entrance, or, in cases of emergency, the outer entrance also.

Fig. 1 also shows the approach channel which is to be dredged to a depth of 30 ft. and to be guarded at the entrance to the dock by concrete walls supported by timber cribs. Between these guide piers and the rolling caisson a sill for the floating caisson is provided. It will be located 20 ft. from the face of the former and will enable it to be unwatered when repairs are necessary.

As shown in Fig. 3, the dry dock will be 144 ft. wide at the top of the coping and 120 ft. in width at the caisson seats. The width will be 120 ft. at the bottom. The depth is approximately 40 ft. below high-water at ordinary spring tide, the fluctuation being 18 ft. between tide levels. The cross-section shows the two solid concrete

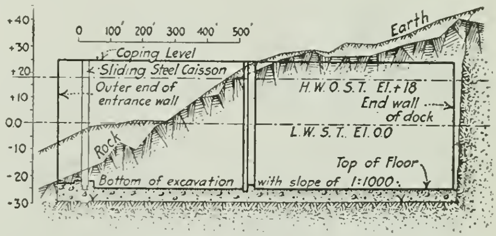


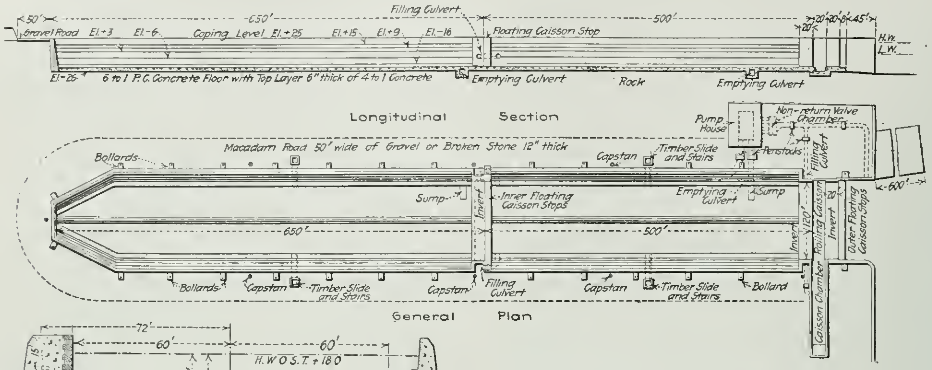
Fig. 2.—Profile Showing Excavation Necessary.

side walls integrally connected to the floor, which is also of concrete. The footings are on solid rock.

The excavation is being carried to a depth of 28½ ft. below the level of low-water spring tide, which is used as the datum line. This is the depth required at the inner end of the dock, the depth of rock varying, as shown in Fig. 1. The bottom of the excavation will have a slope of 1:1,000. It will be 122 ft. in width, sloping up to ground level on a 1:2½ batter. The slope of 1:1,000 mentioned above brings the forward end of the cutting approximately 29½ ft. below datum.

The solid concrete side walls of the dry dock are to be of gravity type in places where they have to support earth fill, such as at the entrance, where the rock bottom recedes considerably, otherwise, the concrete walls will line the rock face of the excavation, retaining on their inner face the same profile as the gravity walls. Where stepped, they will have an average wall thickness of about

5 ft. of concrete. Whenever the gravity walls are built higher than the natural surface of rock they will have a 6-foot thickness of backfill of puddled clay, behind which ordinary earth filling will be used. The coping at the top of the wall and on the altar levels will be of cut granite, toward the outer entrance of the dock being 1 ft. in 1,000. The sides will be drained by two 6x12-in. gutters. Underdrains, beneath the floor and behind the side walls will remove any seepage water. The floor will be built of plain concrete in sections similar to the walls, the in-



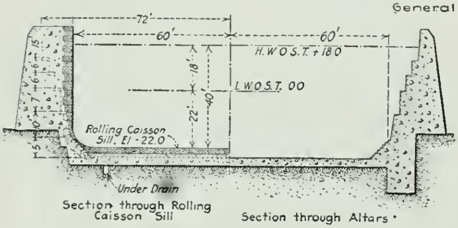


Fig. 3.—General Plan, Longitudinal and Horizontal Sections of Dry Dock.

terstices to be grouted on completion. One feature of the floor formation that deserves special mention is that it will be provided with three rows of granite blocks 18 ins. in thickness, down the centre. The middle row will be 4 ft. in width and will be level on the top, while the row on either side will be 3 ft. wide and will conform to the slope of the floor.

As noted in Fig. 3, the head of the dry dock tapers to a point, in plan. The elevation shows that the altars are not continued but end in a plain sloping gravity head-wall.

On each side of the dock and at each end of the main sections stairs will be moulded into the concrete side walls. Timber slides will also be set centrally in each wall of both sections and at right angles to the dock walls. They will be 8x12 ft. in size and will slope backward from the bottom of the dock to ground level, as shown in Fig. 4. These are shown in Fig. 3, being placed on either side and near the centre of each section. The slides will be faced with granite 18 ins. thick, each block not less than $3\frac{1}{2}$ x 4 ft. in top surface.

in blocks 12 ins. thick and 3 ft. in width in the latter instance and in the form of granite slabs in the former.

The side walls are to be built in 30-ft. sections separated by a ¼-in. expansion joint. Each section will

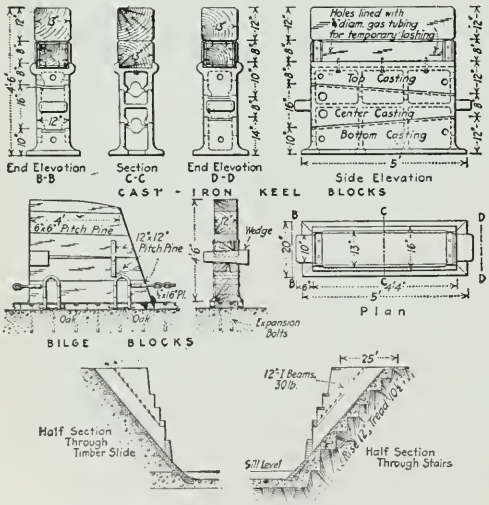


Fig. 4.—Details of Blocks and Block Slides, Also of Timber Slides.

be finished with a V-joint 1 in. in depth. The flooring of the dock will be 5 ft. in thickness, the elevation at the centre being 6 ins. higher than at the sides and the slope

Pumping Equipment.—The following is extracted from the specifications governing the pumps and power units:

The contractor shall furnish and set in place on suitable foundations and at the required elevation, six wrought-steel water-tube boilers each of sufficient capacity to furnish 500 h.p. and two boilers of 300 h.p. each, working under steam pressure of 200 lb., set in batteries of two boilers each. Each boiler may be built with two or more drums not exceeding 48 in.

The boiler should show an efficiency of 75% when fired with good coal containing 12,500 B.t.u. or over per pound.

There shall be three direct-current generators, 550 volts, one of 1,500 kw., one of 750 kw. and one of 300 kw., each driven by steam turbines of the Westinghouse-Parsons type, or by triple-expansion reciprocating vertical engines capable of developing 25% overload. These generators shall be built so as to allow the connections in multiple when required. A lighting direct-current gen-

erator shall also be installed of 100 kw. 220 volts to be driven by a vertical direct-connected compound engine mounted on same bed plate.

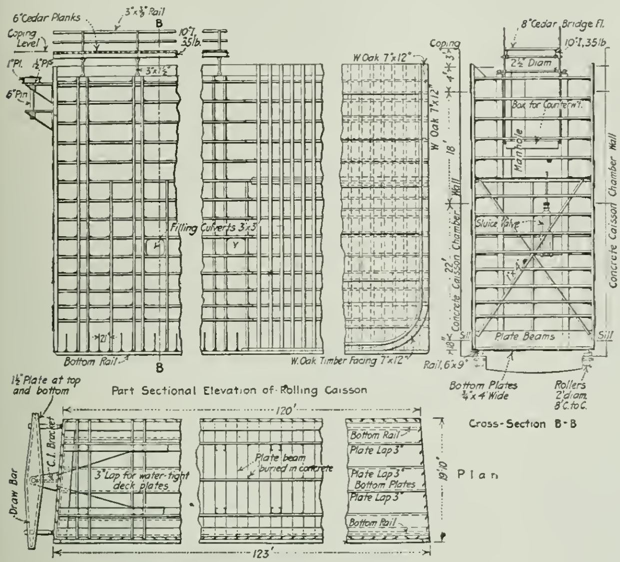


Fig. 5.—Elevation and Sections of Rolling Caisson.

The contractor shall furnish and install the following direct-current motors: three motors of 1,000 h.p. each for the main pumps, 550 volts of suitable speed for pumps; two motors of 125 h.p., 550 volts for the auxiliary drain pumps and of suitable speed; one motor of 125 h.p., 550 volts geared to worm operating the rolling caisson, speed, about 300 r.p.m. and reversible; one motor on rolling caisson, 15 h.p., 550 volts, with shaft extending on both sides and each end carrying three pinions and bevelled gear to operate the six caisson valves; four motors of 15 h.p. each 500 volts, provided with pinions and bevelled gear to operate the main culvert valves; two motors of 100 h.p. each on the floating caisson to operate the pump thereon; one motor of 10 h.p. with pinions and bevelled gear, fitted as specified for the motor on the rolling caisson to operate the sluice valves in the floating caisson. If required so to do, the contractor shall also install motors to operate any of the capstans to be placed on each side of the dock, in which case the motors shall be so installed as to be protected from dampness and rain and made detachable from their foundation.

The contractor shall furnish and install the undermentioned centrifugal pumps for the dock equipment, three main pumps of the vertical type to be placed in the pump house, each having a capacity of 60,000 Imp. gal. per minute, with suction and discharge pipe 58 in. diameter; the suction pipe to be provided with a bell-shaped extension; it shall be supported by angle irons riveted on the outside and fitted in the concrete floor of the pump house, the discharge pipe being solidly fitted in the wall of the non-return valve chamber.

These pumps to have cast-iron impellers, bronze shaft and cast-iron casing with two suitable bearings provided with forced oiling device and the shaft connected to the motors with flanges, all of which to be provided by the contractor and installed in perfect working order. These pumps shall show an efficiency of 72% when working against a head of 25 ft.

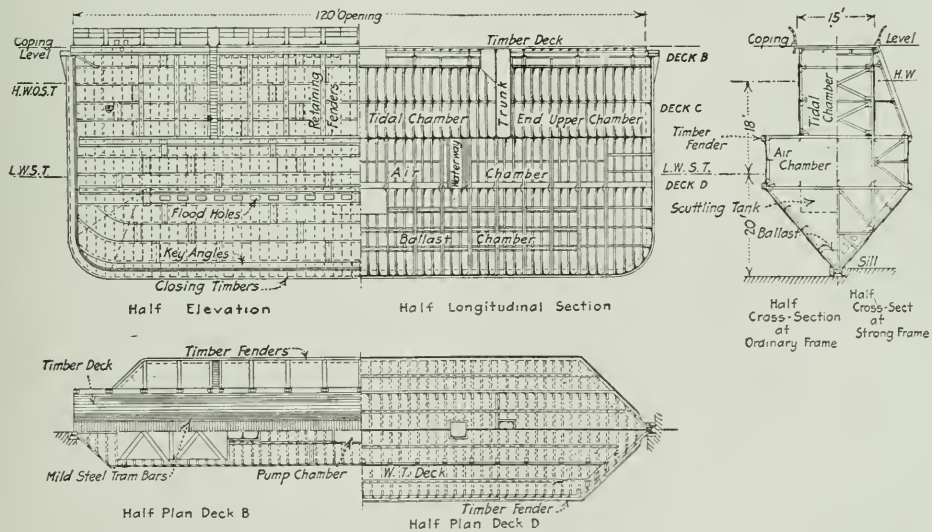


Fig. 6.—Elevation, Plan and Sections of Floating Caisson.

The contractor shall furnish and place in the pump house two drain centrifugal pumps of the vertical type with 18-in. suction and discharge pipes. The suction

shall be provided with a bell-shape extension and foot valve; proper means shall also be provided to charge the pumps. These shall have cast-iron impellers fitted on bronze shafts which shall be flange connected to the motor shaft. The discharge pipes shall be supported on bracket fastened to the walls of the pump house and carried to the main emptying culvert of the dock. A sluice valve shall be provided in the discharge pipe for closing same.

These pumps are intended to work against a head of approximately 40 ft. and shall show an efficiency of 70% when working against that head.

Caisson Gates and Entrance Walls.—The entrance walls mentioned above, and shown in Fig. 7, consist of timber cribs supporting on the top a mass concrete gravity wall 18 ft. in height. They will be 600 ft. in length and funnel-shaped in plan, giving an outer entrance width of 300 ft. The walls are to be each 75 ft. in width. The type of construction consists of a stone foundation to be laid on the earth bottom for a depth of 4 ft., this to be covered by smaller stones to a depth of 1 ft. On top of this the timber is to be laid to an elevation of 6 ft. above low-water. The timber formation is to be filled with stone and to be floored at the top to carry the concrete structure. The space between the concrete walls is to receive earth filling.

The entrance walls approach each other until at the outer entrance of the lock the width conforms approximately to the width of the dry dock. The steel rolling caisson, shown in plan and sectional elevation in Fig. 5, will vary in length from 120 ft. on one side to 123 ft. on the other. It will be 19 ft. 10 ins. in width and is to take the form of a hollow steel frame box properly ballasted to adjust itself in a floating position when in the water. A concrete chamber, shown in Fig. 3, is provided for housing the caisson when not in use. The caisson will be provided with a steel water-tight deck 22 ft. in height. On this the rising tide will be allowed to enter through openings permitting flooding at the rate of 4 ft. in height per hour. This will prevent the caisson from floating in times of flood tide. The caisson will be provided with filling and emptying culverts, as shown in Fig. 2. There will be six of them, each approximately 10 ft. square and constructed of steel and water-tight. When the caisson is to be pulled out of its chamber and across the dock to form the closure its weight will be transferred on rollers by rails shown in the cross-section of Fig. 5. These rails are to be 6 x 9 ins. in section and to be of medium hard steel. The large sectional area is to prevent deflection at times when the caisson is undergoing repairs and there is no hydrostatic pressure underneath. The rollers are to be 2 ft. in diameter and placed 8 ft. centre to centre. The caisson chamber is to be covered with white pine 4 ins. thick resting on steel I-beams placed 30-ins. centre to centre, set in the concrete wall.

Fig. 6 gives details of the floating caisson which is to be used to close the inner entrance under ordinary conditions or the whole dock in cases of emergency. It will be constructed of mild steel and will have water-tight ballast, air and tide chambers, etc., such as are common to floating gates to provide for easy handling when afloat. It will also have 6 filling culverts similar to those already described. It will be equipped with two centrifugal pumps, having a total capacity of 10,000 gal. per minute against a head of 40 ft. These are to be used to remove water ballast when necessary. The caisson is to be provided with timber sills and sides, designed to butt against the sills and vertical walls built into the concrete side walls at the junction of the two main sections of the dock. When the full length of the dock is to be used this floating caisson is to be towed outside of the dock altogether.

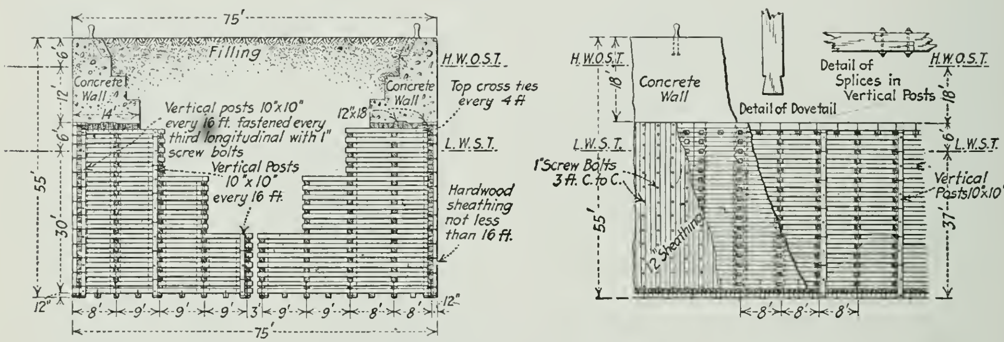


Fig. 7.—Details of Entrance Cribs.

The method of filling and emptying the dry dock is as follows: The culverts are arranged so that each part of the dry dock may be filled or emptied independently. Water is admitted through the filling culverts, shown in Fig. 2, and led into the front part of the chamber around the rolling caisson. The rear chamber is filled through a culvert curving around the floating caisson, as shown by the dotted line. When it is stated that one chamber may be filled or emptied independently of the other it is to be noted that the rear chamber cannot be filled unless the front chamber is full of water. In emptying, the water is conveyed through the sumps beneath the side walls, as shown in the illustration.

When the dock is in use the vessel will be supported by blocks, shown in Fig. 4. The cast-iron keel blocks are to be in three pieces, as shown. Altogether they attain a normal height of 4½ ft. They will be capped with timbers 13 ins. square. The bilge blocks will be of pitch pine provided with sliding irons and oak slide blocks. The bilge block slides will be of white oak and will be situated along the entire length of the dock at 16 ft. centre to centre.

The contract, as stated, was awarded to Messrs. M. P. and J. T. Davis, of Quebec, who are at present engaged upon the work. We are indebted to "Engineering News" for the drawings illustrating this article.

PETROGRAPHIC RANGE OF ROAD-BUILDING MATERIALS.

IT frequently falls to the lot of a petrographer to classify stone which it is proposed to furnish for a special piece of work, and to give an opinion as to its fitness or its likelihood of meeting the requirements of specifications. In most cases these requirements are very far from being specific, in a petrographic sense, i.e., precise rock names are rarely used, whereas some general term or some phrase descriptive of the quality is common. The commonest term of all is "trap."

A few quotations copied from standard specifications covering regular contracts under various state and municipal departments, and bureaus of highways, are given as representative of this usage by Mr. Chas. P. Berkey, in the School of Mines Quarterly of Columbia University:

(*a*) "Only broken stone . . . of a hard and compact texture and of uniform grain will be allowed . . . . Disintegrated and rotten stone . . . will not be accepted."

(*b*) "The trap rock shall be of satisfactory quality equal to that used in . . . for macadam roads."

(*c*) "The mineral aggregate used shall consist of trap rock, newly broken, of uniform quality throughout, free from slaty and flat pieces, soft or disintegrated stone, dirt and other objectionable material."

(*d*) "The stone . . . must be trap or approved native rock. It must show a fresh, crystalline surface."

(*e*) "All stone must be . . . the same kind and quality, equally good in every particular as that shown in the Engineer's office."

(*f*) "Only good, solid stone shall be used. . . . Bidders will name the kind of stone they propose using in said work, also its location."

(*g*) " . . . shall consist of first quality trap rock . . . Mineral aggregate shall be clean, crushed trap rock of approved quality."

(*h*) "Crushed stone shall have a coefficient of wear, according to the Duval test, of not less than 8, and a cementation value of not less than 50."

(*i*) "The first course shall consist of sound rock . . . Unless otherwise specified, the stone of the second course shall be trap rock. . . . For the third course other material than trap rock screenings may be used if approved by the Engineer."

(*j*) "Stone for macadam shall consist of approved local stone, trap rock, or a combination of local stone and trap rock . . ."

(*k*) "The crushed stone shall be trap or other suitable rock, satisfactory to the office in charge."

(*l*) "The macadam shall be of limestone of approved quality. . . . The stone must be of good and uniform texture."

(*m*) "All stone for concrete shall be hard limestone, sandstone, trap, furnace slag, quartzite, or granite, acceptable to the Chief Engineer. Broken stone must be quarried from massive ledge, and any stone which shows a tendency to break into flat, thin pieces will be rejected."

(*n*) "The broken stone shall be trap, granite, or limestone, or such other stone taken from the line of work as shall be satisfactory in the judgment of the Engineer."

Such a summary is probably fairly typical. From it two or three generalizations may be made. For example: (1) The standard, so far as there is a standard, with which all rocks are compared in highway work, is "trap." (2) Trap is usually specified by name wherever there is any reasonable hope of furnishing it for the contract. (3) Wherever substitutes are encouraged they are either indicated by name, or are described in efficiency terms, or the responsibility is placed directly on the engineer in charge.

It is the general opinion, based on experience, that the "traps" are pre-eminently satisfactory for highway uses. But trap is not a very definite petrographic term. In a very broad way this means that the basic igneous rocks of massive structure, and having a tendency to diabasic or closely interlocked habit of the mineral constituents, are the best road material. The acid igneous rocks are not so successful, especially when there is heavy traffic sufficient to test the toughness of the rock. The metamorphic rocks, as a class, are not regarded with much favor. The clastic or fragmental rocks, as a rule, are not recommended, but limestones are very serviceable where hardness is not a prime essential. In every large class of rocks there are special types which prove to be of acceptable grade, but no large class compares with the basic igneous rocks for general efficiency under the most exacting conditions.

In spite of this apparent reduction to such simple terms in the matter of range of rock types regarded as acceptable, as a matter of fact, a great variety of rocks are actually used and are quite worthy of serious consideration. Many factors enter into the question of choice; it is not always a simple problem. There is little excuse for a community to demand trap in any except the most critical cases, unless there are trap ledges in the vicinity or somewhere near its borders. It may well happen, in many cases, that the increased efficiency is more than counterbalanced by the extra cost over local stone. In the average case, local stones everywhere merit serious consideration, and a little judicious discrimination will usually discover an acceptable one.

It is in this connection that critical knowledge of rock variation will be found useful. Names of rocks alone are not so useful as might at first appear, because all types vary greatly in minor points of texture, structure, chemical and dynamic modification, and consequent efficiency. No amount of mere classification can take the place of careful discrimination of structural variety within the principal types themselves.

It may be useful, however, to consider briefly the range of types coming within observation for such uses, and to indicate their petrographic grouping. Probably no publication on rock for highway uses has given a fuller list of varieties than Bulletin 44 of the Office of Public Roads, United States Department of Agriculture, Washington.

The following list has been compiled from this and other sources, and the terms are classified under the commonly used headings familiar to all students of natural rock materials. In it there is no attempt to indicate relative value for actual use. For reasons suggested in an earlier paragraph it is certain that particular varieties of a type which is usually considered of poor quality may very well prove to be much superior to the more faulty varieties of rock types that are generally regarded as high-grade. The descriptive terms following some of the rock names indicate the varieties that have been used; the terms are inserted just as they occur in the literature, without any attempt to reduce them to uniformity::—

I. Igneous Rocks:

(*a*) Volcanic fragmental materials:

1. Volcanic ash.
2. Volcanic breccias.
3. Rhyolite tuff.
4. Andesite tuff.
5. Basalt tuff.

(*b*) Surface flows (crystalline lavas, felsitic, and slightly porphyritic in texture and showing flowage structure):
6. Rhyolite and rhyolite breccia.
7. Felsite and brecciated felsite.
8. Trachyte.
9. Andesites: Augite; Hornblende; Andesite breccia.
10. Basalt: Vitreous; Olivine; Chloritized.

(*c*) Intrusive masses (dikes, sills, etc.; strongly porphyritic or intimately interlocked in texture):
11. Granite porphry.
12. Syenite porphry.
13. Camptonite.
14. Diabase ("trap" of highest grade): Hypersthene; Uralitic; Olivine; Augite; Gabbro; Meta-diabase.
15. Diabase porphry.
16. Peridotite.
17. Pegmatite.

(*d*) Plutonic masses (deep-seated in origin; granitoid in texture and massive structure):
18. Granite: Hornblende; Porphyritic; Muscovite; Micro-granite; Gneissoid.
19. Syenite: Augite; Quartz.
20. Granodiorite.
21. Diorite: Quartz; Augite; Basic; Porphyritic.
22. Gabbro: Hornblende; Hypersthene; Uralitic.

In the above grouping, the field relations are indicated in the sub-headings, and under each the rock types of which the names have been found mentioned in road tests, or rock lists for such purpose, have been arranged approximately in order from the more acid to the more basic in composition.

II. Sedimentary (clastic) rocks and associated organic accumulations and aqueous precipitates, together with special modifications:

(*e*) Simple sediments (arranged from fine to coarse grain):
23. Shale: Clay; Ferruginous; Carbonaceous; Calcareous.
24. Sandstone: Argillaceous; Calcareous; Ferruginous; Chloritic; Feldspathic; Arkose; Kaolinized; Biotite; Indurated; Metamorphosed; Conglomeritic.
25. Conglomerate.

(*f*) Organic in origin, with or without sedimentary intermixture, and usually with some modification:
26. Limestone: Shell; Fossiliferous; Clay; Argillaceous; Bituminous; Siliceous; Nodular; Oolitic; Cherty; Dolomitic.
27. Dolomite: Argillaceous; Arenaceous; Siliceous.

(*g*) Precipitates:
28. Travertine (tufaceous limestone).
29. Gypsum.

(*h*) Special segregations, etc.:
30. Quartz.
31. Chert: Calcareous; Oolomitic.
32. Flint.
33. Nematite.
34. Phosphate rock.

III. Dynamic fragmental materials:

(*i*) 35. Breccia: Quartz; Quartzite; Brecciated felsite.

IV. Metamorphic rocks (that have been recrystallized and have lost most of their original structural habit and in part their mineralogic habit. As a rule they have a foliate structure and break much more readily in one direction than in others):

(*j*) Fine-grained types (with good rock cleavage):
36. Slate or argillite: Clay; Siliceous; Calcareous; Indurated slate.

(*k*) Medium grained (rather massive and comparatively little foliate habit):
37. Quartzite: Calcareous; Sericitic; Feldspathic; Chloritic; Pyroxene; Epidote; Hornblende; Micaceous.
38. Graywacke.

(*l*) Strongly foliated and usually of medium grain (commonly of abnormal composition; i.e., some mineral other than feldspar in excess):
39. Schist: Quartzite; Mica; Biotite; Quartz-mica; Hornblende; Mica-hornblende; Hornblende - mica; Chlorite; Hornblende - chlorite; Garnet - hornblende; Quartz - hornblende; Tremolite; Talc schist (soapstone).

(*m*) Foliated structure, medium to coarse grain, sometimes banded and of normal composition (i.e., the usual feldspathic mineral makeup):
40. Gneiss of unstated relations: Quartz; Sericite; Hornblende; Arkose; Chlorite; Muscovite; Biotite; Pyroxene.
41. Granite gneiss.
42. Syenite gneiss.
43. Diorite gneiss.
44. Gabbro gneiss.

(*n*) Massive types:
45. Marble: Dolomite marble.
46. Serpentine: Hornblende serpentine.
47. Amphibolite.
48. Eclogite: Mica eclogite.
49. Epidosite.

This list represents in reality a very wide range. It is certain that many of them are of very low efficiency, but in spite of that they have been found worthy of consideration and test. Nos. 10, 13, 14, 15 and 21 are the prominent "trap" representatives. Diabase, No. 14, is the type usually meant when the term is used in specifications. But it is not a closely defined petrographic term and is often more loosely used.

The fact that these rock names appear as having been considered worthy of attention for road-building purposes does not necessarily indicate special fitness of all these types. Many of them are doubtless very poor grade compared with trap, but they may in spite of that be superior to the only other materials warranting practical comparison in a given case. Furthermore, the fact that any one of these has been used successfully cannot be taken as evidence that every occurrence of the rock of the same petrographic classification would be acceptable, since so much depends on the physical condition, freedom from decay, texture and special structural factors of each occurrence—to say nothing of other factors of control lying outside of the present line of discussion—such as availability of other competing materials, transportation difficulties, allowable cost, uses to which the road is to be put, etc.

No doubt it would be a great convenience for highway engineers if a special classification, in which the pro-

minent efficiency factors were given chief place, could be devised. The chief difficulties with such a scheme are:

(1) That it is an attempt to simplify data that are essentially not simple.

(2) That its basis could not coincide at all with that of any other rock classification; and, therefore,

(3) That the terms used in classification could not agree closely with those in common use.

The result would be, it seems to me, that we should have another classification to become familiar with instead of accomplishing a simplification. On the whole, there is as yet no better suggestion than that the commonly used terms for description and naming should be thoroughly mastered, and that the nature of the structural and textural basis of difference in quality should be fully understood, and that the geological and petrographic principles underlying the history of rocks should be a part of ones professional equipment.

ELECTRO-THERMIC MANUFACTURE OF STEEL.

This is a comparatively new industry, dating from about the year 1900. The advantages of heat produced electrically, for the manufacture of steel, over that produced by chemical reaction through the combustion of fuels are four in number. It is obvious that almost any temperature within reason can be obtained, and consequently slags rich in lime, and with a strong affinity for sulphur and phosphorus, can be smelted whose melting point is too high for the ordinary methods employed. It is also possible to deal with the titaniferous ores, which make the furnace charge too infusible for coke smelting. Alloys can likewise be produced which are too infusible to be formed in fuel-heated furnaces, such as ferro-titanium, ferro-tungsten, ferro-chrome, or ferro-silicon, which are richer than usual in the alloying element.

A second advantage is that an exactness and nicety in the control of temperature can be obtained, giving increased facility to the control of chemical reactions within the furnace, so that certain combinations of elements in the iron are made possible and the temperature at which the steel is finished and cast may be more exactly regulated. The metal obtained is also free from contamination by impurities contained in the fuel; the chief of which is sulphur, which is always present in the coke. Another point which has to be taken into consideration is that electric power for smelting purposes can often be obtained from some watercourse adjacent to the ores and fluxes, in situations where gas, oil, coal, or coke could be procured with difficulty.

GAS PLANTS AND MACHINERY.

The president of the Institution of Gas Engineers in England was reported recently as stating that with the exception of the method of heat purification, there has not been any striking change in either plant or machinery in the gas industry for some time past. The problem of carbonization is receiving close attention, but it is to be regretted that the committee appointed by the institution has not yet been able to arrange for the comparative tests being awaited by the industry as a whole. Of late, increasing attention has been given to questions of scrubbing and condensation in order to remove deleterious substances from crude gas in such a way as not to impoverish the finished product, and in such a way as to ensure that nothing remains that will impose an unnecessary burden on the purifiers, or interfere, or tend to interfere, with the value of gas as an illuminant and a heating agent.

WATER AND SEWAGE INSTALLATION AT ASSINIBOIA, MAN.

The water and sewer systems around Deer Lodge, in Assiniboia, the western suburb of Winnipeg, were officially opened on August 12th. If the plans of the Assiniboia council are compassed, water and sewer main connection will be carried from the Winnipeg city limits to Sturgeon Creek. The plans have been made and are being carried out with the end in view that, when the time comes to connect up with the Greater Winnipeg Water District scheme, the connection will be ready and easily completed. The new system has, moreover, been constructed so as to afford a means of protection against fire.

Under supervision of G. W. Rogers, A.M.I.C.E., the municipal engineer, the new system has been installed with most creditable speed. Work was started last November, and since that time nearly 7 miles of sewers and water mains have been laid. The work, when complete, will cost approximately $200,000.

The water is obtained from an artesian well, 365 feet deep; and a small pumping station 52 x 30 feet in dimensions, has been erected.

The pumping plant is complete in every detail and has a capacity of 12,000 gallons an hour. It will supply a population of 2,000. All the machinery is in duplicate, so that in the event of a breakdown the water supply will not be shut off for a single instant. The electrical equipment consisting of two 25-h.p. units, together with the arrangement of switch board and all the electrical apparatus, was installed under the direction of R. Lynn, the municipal electrician. There is a 70-pound pressure at the head of the pumps. The building and solid concrete foundations upon which all the machinery and storage tanks rest were erected by the Progress Construction Co. The entire machinery plant was put in by the Refrigeration and General Engineering Co., of Winnipeg; which firm, in addition to installing the plant, put in a complete system of fire hydrants, which are distributed all over the district.

In the pumping station, probably the most important installation is that of 2 steel tanks, the combined capacity of which is 36,000 gallons. There will always be this amount of water in reserve in addition to that around the well. Outside the building there is a concrete tank, the top of which is flush with the ground. This tank is 13 feet deep, 12 feet in diameter, and has a capacity of 5,000 gallons.

The system employed at the new plant is to pump the water from the well to this outside tank with 2 air compressors. It is then pumped into the 2 steel tanks within, and from there into the mains under air pressure. In this manner the water is aerated to a certain extent. The plant is so arranged that water can be pumped directly into the mains in case of fire. The system of laying the water mains is such that in case of a leak it will only be necessary to shut off a small area until excavations are made and the repairs attended to. This sewage is discharged directly into the Assiniboine River by gravitation, the high water-mark being much lower than the residential district.

The figures contained in the report of the superintendent of Mines for the Province of Quebec show that in the course of the last fiscal year, the mines of Quebec yielded a production of 13,119,811, or nearly 2,000,000 more than in 1912. As usual, asbestos leads all mineral products, the quantities extracted reaching the value of $3,839,504. Quebec Province alone produces 80 per cent. of the world's consumption.

THE EVOLUTION OF RAILWAY MOTOR GEARING.*

By W. G. Carey.

THE design of the gear equipment of the first small electric railway motors was adapted from established practice in the construction of gear trains in stationary apparatus. Abundant space was available for adequate cast iron gears. With increase in size of motors it became convenient to substitute cast steel for cast iron in order to secure increased strength while conserving interchangeability on existing trucks; and thereafter for many years cast steel gears with machine steel pinions continued to be used in universal practice. The speed reductions from the armature shaft to the axle ranged from about 3 to 1 to 4.78 to 1, and pinions and gears wore out in about these ratios. The obvious advantage of increasing the life of the pinion to approximately that of the gear in order to improve average conditions of mesh and to reduce the cost of frequent renewal of pinions led to early experiments in case-hardening of pinions. In applying this process, practice satisfactory in other arts was followed and little attempt was made to modify, for the special conditions, the process as usually carried out. The first case-hardened pinions exhibited consequently a considerable measure of warping from the heat treatment, which fact involved high cost in rejections in manufacture. Also, this warping and other results of the treatment caused in many cases destructive wear of the companion gear, and the net results were such that no really great interest in any form of heat treatment of gear-

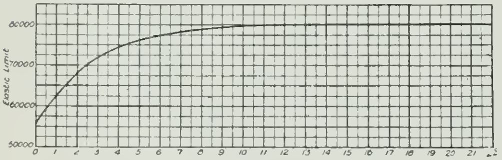


Fig. 1.

ing was felt until increased size of motors, for which aa active demand was arising, made imperative an increase in the strength of materials. The pitch of teeth and width of gear face had been increased to the limit allowed by available space on the trucks, and the strongest cast steel practicable for machine operations was found inadequate; therefore, to meet the severest conditions resort was had to alloy steels, with partial success in keeping equipments in service. Experiment to determine the alloy steels best suited for the purpose required, however, a long time and involved heavy expense, and heat-treated carbon steels tried out at the same time afforded excellent results. Painstaking study by manufacturers of railway apparatus, aided by the broadminded co-operation of operating engineers, soon resulted in the determination of suitable material and the development of methods in heat treatment adequate for the severest conditions in present normal practice.

Incidentally, the modification of the material and its heat treatment, together with increased strength, produced considerable increased hardness, and, at least for city service where the strength of untreated gears was still adequate, the old idea of a pinion harder than the gear, tending to equalize the life of the two, was in a measure realized, and within a very short time the untreated pinion was entirely discarded, even for service in which the strength of the heat-treated steels was entirely unnecessary.

Only experiment could determine certainly the effect of the hard pinion on the untreated cast gear, and some curious results developed in special cases. In one of the first installations on a considerable scale the hardened pinions wore out completely in about half the life of the old untreated machine steel pinions, and this proved to be due to the presence in the gear grease of considerable quantities of very hard sand prevalent in the neighborhood, which, getting into the gear case, became embedded in the surface of the soft gear teeth, forming a lap for the rapid destruction of the pinion teeth. On the whole, however, with good methods of lubrication and maintenance of equipment, heat-treated pinions having a hardness not exceeding approximately 300 in the Brinnell scale appear to afford greatly increased life without measureable reduction in the life of an untreated companion gear.

Continued experiment in case-hardening developed means of avoiding most, if not all, of the original trouble of warping in treatment, and the process was applied experimentally on a considerable scale to the cast gears as well as to pinions; and increased life, altogether out of proportion to the increased cost, was immediately obtained. Split gear castings, however, still gave some trouble from warping on account of their irregular sections. At that time split gears were in considerable demand, although the use of solid gears had already commended itself strongly for many reasons. Split gear bolts had always given trouble and it was easier to obtain sound castings in the more regular sections in the solid gear, and these considerations had begun to have a considerable influence in hastening the provision, in repair shops and inspection barns, of wheel presses and other facilities for handling solid gear equipments. In the present state of the art of case-hardening pieces of such size and shape as motor gears, this matter of warping is not so serious a matter, as its control has been greatly improved; but at that time a general readiness to substitute solid gears greatly facilitated the trial of case-hardened gearing on an extensive scale in service.

This material is essentially a low carbon steel with the surface impregnated with additional carbon and heat-treated. The usual practice is to shroud portions not required to be hardened so that only the tooth surfaces are exposed to the "cementing" process, as the incorporation of additional carbon is called. Therefore, only the carburized portion hardens in quenching. It is usual practice to carry the depth of impregnation of carbon in the tooth surface to about the limit of allowable wear, which, in three-pitch gearing, is approximately 1/10 in. This, however, is subject to very definite control and is varied within limits for various conditions.

The surface of case-hardened gear and pinion teeth shows hardness about 95 in the scale of the Shore schleroscope. It is not practicable to measure this material with the Brinnell instrument for the reason that the uncemented core will not stand up under the pressure necessary to effect an indentation, and such pressure also causes deformation of the pressure ball. The schleroscope is also to some extent misleading, as different conditions, such as size of parts tested or method of their support in test, give rise to considerable inaccuracies. In experienced hands the most reliable comparison of hardness of specimens of materials of this class is a file test, though this may be entirely misleading in comparison of different alloy

*From the General Electric Review.

steels. Modern case-hardened carbon steel which gives a schleroscope reading of 95 can just be scratched with a very fine Swiss file.

This class of gearing, because of the price at which it could be marketed, was manifestly a great improvement in economy of operation, wherever it might be found sufficiently strong to withstand the shocks of service. No test, other than that of service, has been devised for determining its resistance to service stresses, but that the limit of its strength is below the requirements of the heaviest modern service appeared probable and has since been demonstrated. In the first days of its use much virtue was attributed to the toughness of the low carbon core, but this toughness cannot manifest itself under stresses on the whole tooth, and a tooth strained beyond its strength breaks short. It is evident that substantially the entire tooth strength must be found in the hardened case, and the factor of safety, even with the enormous elastic limit of this high carbon case, promised to be too low for safety in the heaviest equipments throughout the very long period of its probable service. Although this gearing has been used very conservatively on motors of

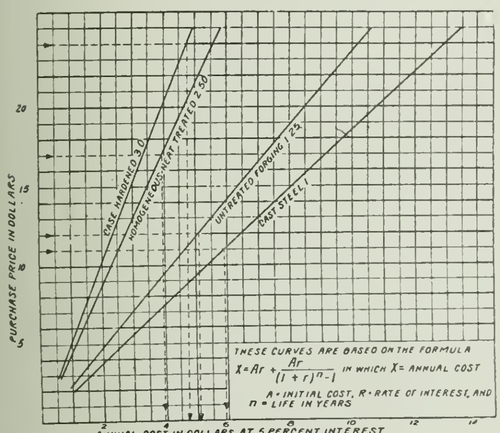


Fig. 2.

over 125 h.p., and then only in the light of careful study of operating conditions, the original estimates of strength have been closely borne out. Breakage has occurred in certain carefully watched test equipments after two years of service where wear had hardly begun. This has in some cases undoubtedly been due to fatigue of the case from repeated shocks closely approaching the elastic limit, and in other cases to subsidence of the soft tooth core resulting in cracking of the case.

It is therefore known to-day that, while with motors of less than about 100 h.p. this type of gearing is sufficiently strong to resist fatigue until worn out in service, its application with heavier equipments can only be advised in the light of a very definite understanding of the conditions of operation. With such heavier equipments, especially in high speed service with rapid acceleration and liability to abnormal shocks such as are produced by commutator flash-overs or line breaks at the collector, the case-hardened gearing appeared and has already been proved to have an inadequate factor of safety.

Attention was then turned to a modification of the homogeneous heat-treated gearing with a view to increasing its hardness to attain increased life and a greater elastic limit, which was essential in order to defer fatigue beyond the extended limit of wear. The physical characteristics of heat-treated steels depend upon a considerable number of variable factors in the constitution of the steel, the manner in which it is worked, and methods of treatment. The constitution of the material can only be definitely controlled within certain limits which are well recognized in steel manufacture, and variations in the constitution affect final physical characteristics, though the variations may be corrected in a measure by corresponding variations in treatment. Such methods, if carried to too great a refinement, are prohibitively expensive, and the development of the desired new type of gearing involved a method of analysis and an adjustment of treatment which would be commercially practicable.

The type of heat-treated gearing which had become recognized as a heavy service standard showed elastic limit varying in regular production from eighty to ninety thousand pounds per square inch, although occasionally specimens showed still higher values and certain other specimens with elastic limit varying down to 70,000 lb. per square inch were put into service in the earlier days of this development. Throughout several years a record was kept of mileage and physical characteristics of all specimens broken in a service of known character, and the curve in Fig. 1 shows relation between elastic limit of broken specimens and the time required for fatigue to the breaking point in normal service.

This shows that maximum stresses on the gear teeth, which could be determined in no other way, are equivalent to about 70,000 lb. per square inch in the teeth, since all specimens broken early in service show approximately this value. Higher values are shown to afford longer life, until the specimens broken toward the limit of wear invariably show an elastic limit of approximately 80,000 lb. per square inch, and in no cases have specimens showing higher values broken in service.

With a lower ductility, it was assumed—and it is in all probability true—that a larger factor of safety would be necessary to defer fatigue beyond the limit of wear, and a composition was selected and methods of working and treatment determined which would give an elastic limit of 140,000 to 150,000 lb. This steel shows a hardness approximately 500 in the Brinnell scale, and, while no very definite comparison with hardness of case-hardened gearing is possible, such rough comparison of the Brinnell and schleroscope scales as is possible and the file test indicate the hardness to be approximately 85 per cent. of that of case-hardened gearing.

Commercial application of this type of gearing has been made with the greatest care, and it has not yet been trusted in the heaviest service, although since its first commercial use two years ago about 7,000 equipments of this gearing have been installed with motors of all power up to 150 h.p. and there is no record of breakage of a single tooth within the limit of wear.

It has been pointed out that various factors had contributed to a marked tendency to substitute solid for split gears. This tendency was manifest in all classes of service, and its wide spread made possible the realization of an old idea of using forged blanks in place of castings for axle gears.

The manifest advantage of forgings in entirely eliminating shrink strains and other faults not altogether avoidable in castings was important, but not all of the desired end. It was practicable to machine steel of a higher carbon content, and the strength and toughness could be greatly enhanced by the operation of forging the

blank. The very great diversity of combinations of shape and dimension required involved an enormously expensive development cost and it is probable that this would have long deferred the general substitution of forged for cast solid gears, were it not for the fact that the development of the homogeneous heat-treated types absolutely required forgings, since the desired physical characteristics were unattainable in castings. The cost of manufacture is so far a little higher, but the difference would probably be justified by the certain and invariable integrity of the blank, even with the same life factor. In addition, however, the untreated forged gear shows approximately 20 per cent. higher elastic limit and nearly 25 per cent. greater hardness, and these characteristics afford an increased life approximately proportional.

There are then available in the art to-day three modern types of gearing, each of which may have its appropriate field, although there may be some difference of opinion as to where and to what extent these fields overlap. The first essential in the selection of a type is adequate strength for positive assurance against breakage within the limit of wear.

There are thousands of motors in operation which are destined to be superseded by more modern machines within the expected life of heat-treated gearing, and in such cases no advantage can be gained by the use, at higher cost, of a type which cannot be worn out within the life of the apparatus; and therefore the untreated forging is clearly the only type to be considered.

Also, many important systems have been completely equipped with case-hardened gearing, and the problem of changing over to another type, unless the two types can be successfully operated together, is a difficult one, and such a change must be effected gradually. Both of these considerations must be taken into account, although in the end practice will be standardized on the basis, first, of safety and then of annual cost of maintenance.

In the meantime, in substituting complete gear equipments of the modern heat-treated steels for untreated gears with heat-treated pinions having hardness of about 250 to 300 in the Brinnell scale, it is evident that some trouble will be involved in attempting to maintain the proper combinations, and the result of combining gears and pinions of widely differing hardness under all service conditions is very uncertain. While occasional instances of successful operation of even case-hardened pinions with untreated gears are reported, it is certain that such combinations will generally result in reduced life of the softer member, and in effecting changes in their practice most operators are taking the trouble to provide pinions of only moderate hardness for use with their untreated gears and meshing all new gears of more modern types with pinions of the same types.

For the purpose of estimate of maintenance cost, life factors of different types must be assumed and the following are based upon records of service under widely varying conditions.

Grade.	Life factor.
Untreated cast steel	1
Untreated forged steel	1.25
Homogeneous heat treated	2.25
Case-hardened	3

These estimated life factors, with cast steel taken as 1, are about proportional to the relative hardness of the respective types, which factor should, and apparently does, reflect fairly closely the average life in service. Based upon these factors and an assumption of 5 per cent. interest on investment, the curves in Fig. 3 show a comparison of the respective maintenance costs of the four types here considered, at the prevailing market prices of a representative gear for city service.

The market prices of this gear in the four different types are, respectively: cast steel, $11; untreated forging, $12; homogeneous heat-treated, $17; and case-hardened, $24. Following the dotted lines as indicated by arrows from these purchase prices in the ordinates, the respective annual costs will be found to be $5.90 for untreated casting; $5.10 for untreated forging; $3.95 for homogeneous heat-treated, and $4.75 for case-hardened gears.

It has been said that the heat-treated carbon steels now available have proved adequate for the severest conditions in present normal practice. It is known, however, that we are already near the limit of strength of this material, and the added demands of apparatus already projected, and of at least one existing application of somewhat special character, call for an additional factor of safety to maintain strength requisite for service to the limit of wear. Experiment on an extensive scale is being conducted with various alloy steels and various treatments, and encouraging results are promised, particularly with chrome-vanadium. Owing to its narrower base, the strength of the pinion tooth is measurably lower than that of the teeth of its companion gear, and there will undoubtedly be a wide range of applications in which alloy steel pinions may be used with carbon steel gears, and by virtue of an elastic limit of something like 170,000 lb. per square inch, which appears attainable, will equalize the difference and take us another long step in the development of this art in which we are so circumscribed by the fixed dimensions of the trucks.

MECHANICAL WATER FILTRATION.

The results obtained with mechanical filtration of water that is badly discolored and carries large quantities of suspended matter are highly satisfactory. Waterworks engineers may with advantage consider whether flood water which has been allowed to run to waste cannot be so treated as to become of value. Where gravitation works have been designed to take only a portion of flood water it is possible, according to Mr. T. Molyneaux, to extend greatly the resources of the watershed, and so postpone the consideration of some expensive scheme. Gravitation filters are composed of a layer of sand over layers of stones of varying thicknesses, and really are water strainers only. High-pressure filters are cylindrical vessels filled with sand through which water is forced at high pressure. One gallon in every 300 which passes is required for cleaning, which is done by reversing the filter and agitating the sand with radial arms provided in the casing for the purpose.

Before mechanical filtration is taken up on a large scale some amount of consideration must be given to the design of the plant. It has been pointed out that the unit commonly in use is 8 ft. in diameter, and capable of dealing with some 150,000 gallons of water daily; but there seems no reason why a larger plant should not be used. The obstacles in the way would appear to be only mechanical, and as such can be overcome without great difficulty. There is a plant in course of construction in which the units are of 9 ft. diameter, and it will shortly be seen how superior this is to the existing designs.

Mechanically-filtered water would be further improved if it were passed into a service reservoir before being sent into the mains, in order to allow a secondary deposition of matter in suspension, which no ordinary laboratory analysis shows, but which is undoubtedly present.

WARFARE AND THE ENGINEERING PRESS

VIEWS FROM ABROAD OF THE EFFECT OF THE EUROPEAN TROUBLE ON THE PROGRESS OF ENGINEERING.

THE effect of the outbreak and magnitude of European hostilities upon engineers and engineering has been reviewed with a general feeling of confidence by the engineering press. The first expressions of concern, while naturally reflecting retrenchment in constructional activities and readjustment of many factors influencing engineering, exhibit no trace of forebodings of a panicky nature. Even in England, where, according to the daily press, one might expect engineering and industrial work to cease, except that for the production of military supplies, the industries are active, the unemployed are comparatively few, and the British manufacturer has already set to work upon the task of preparing to secure as large a share as possible of the export trade which will be set a-begging when peace has again been secured.

The following editorial observations, which appeared in various engineering papers of England and the United States, should be read carefully by Canadian engineers. There is substantial argument to uphold the belief that the arrest by war of engineering work will not be long drawn out, and that it will be succeeded by greater activity than has been experienced of late:—

We can all perceive the ugly features of the war. Let us note a few of the consolations. Plant to the value of some hundreds of thousands of pounds must be reordered in this country. Against the factories which will run on reduced time must be set several others which have already started overtime. We heard yesterday of an electrical manufacturing firm who were compelled to work all through the last two week-ends. But we are not thinking so much of electrical works proper as of other industries which buy from us. For instance, the big armament firms are working day and night, the electrical equipment of ships has been accelerated, the Reading biscuit firms are on overtime, so are the army clothing establishments, the arsenals and certain dockyard departments.

So that, without wishing to argue that the war is, on balance, a benefit—it is obviously an immense evil altogether—there is not the least occasion for despondency. Our home trade is immensely greater than our foreign trade, and our trade with the affected countries was largely an importation of manufactured goods in exchange for our coal and semi-manufactured products The very considerable imports from Germany and Austria will not simply be dispensed with, to a large extent they must be replaced.

As the Government insure the safety of ocean traffic, America and the Colonies will not be deterred by war risks. Shipping will be continued, after some initial check, with Canada, United States, Africa, Australia, and the East. British manufacturers stand to replace German and Austrian competitors on a large scale, and for many years to come; now is their opportunity. They should supplant them, not only in our home market, but in such neutral ones as South America, an immense purchaser. These firms partly importing and partly manufacturing in this country will probably decide to increase their British works, though not immediately. What we cannot produce ourselves, or get from Europe, we can probably obtain from America or elsewhere. Even the greatest of calamities bring good to somebody or other; the present upheaval will probably divert our trade to different channels. But we sincerely hope and believe that our trade does not, like that of Germany, incur any risk of crushing, or even of arrest, taken as a whole. What, it may be asked, of our sales to Germany? Assuming their stoppage for a long period after the war, it must be remembered by way of consolation that Russia, one of Germany's very best customers, and afflicted with some sentiment in her temperament, will go elsewhere for her manufactured goods. England, France and America can no doubt oblige. Beyond hazarding these few guesses as to the probable tendency of events, it is early as yet to discuss the precise developments. The general summary is that things might have been very much worse. The public are accepting the calamity with unexpected calm, things wear their normal aspect, trams and trains run much as before, the shops are all doing good business, there are really few signs of the upheaval, apart from the placards and the scarcity of London general omnibuses.—*The Electrical Times*, London, August 6th, 1914.

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It is needless to take an alarmist view; on the other hand, it is wise to be fully prepared for the fortunes of war. The municipal engineer has at all times a great responsibility, but in time of war this responsibility is surely increased. To consider one of the many works for which he is responsible—the water supply. The greater the work, the greater is its vulnerability; one man with a spade could easily start a burst in an earthen dam, and one small cartridge might wreck the conduit which supplies a city. How soon might the most perfect pumping machinery be put out of gear or utterly ruined. Again, one may imagine how easily a great sewer might be blocked or even wrecked, and how seriously this might, under certain conditions, affect the district served. The same applies to power and electricity stations, to bridges and to docks. In the case of dock basins the malicious bursting of a wall might easily lead to the wrecking of a large number of vessels, while injury to dock-gates and caissons would be followed by the most serious consequences. It is idle to enumerate or to suggest the various ways in which harm might be done; every engineer knows only too well how easily the greatest works could be injured or wrecked, seeing that they have been designed and constructed for the purposes of peace, and not to withstand malicious attack.

Bearing these facts in mind it is clearly the duty of the municipal engineer at the present time to take every possible precaution against the possibilities mentioned. Reservoirs certainly ought to be watched and guarded where the supply of large communities is dependent upon them; similarly, long, exposed pipe lines ought to be watched. At present it would not be difficult for our country's enemies to damage aqueducts or reservoirs. It is a case in which the municipal engineer should carefully consider what works under his control are sufficiently important and vulnerable to require special

guarding, and next he would do well to see that they are efficiently watched. If his own staff of workmen are insufficient, as may well be the case, it is his duty to call attention to the fact, and the help of the police, military, and territorials may well be required. There will be a very large number of persons ready and willing to serve their country at the present time. These might be employed in guarding municipal works, but such service will be useless unless it is first directed by the municipal engineer. There are other dangers incident to a state of war. The bridges and highways may need special protection. Excessive loads may come upon them, and it is the duty of the municipal engineer to see that these are strong enough to sustain the loads, and where necessary to make provision for temporarily strengthening them. We do not wish to adopt any alarmist attitude; happily the risk of actual invasion is extremely remote. There are, nevertheless, other chances of trouble which should not be overlooked, and the proper guarding of municipal works at the present time is a duty which should be brought prominently forward, seeing how vitally the well-being of every citizen is affected.—*The Surveyor*, London, August 7th, 1914.

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The entire world must suffer on account of the terrible European situation, if not directly in loss of life and property, at least in temporary financial embarrassment. American financiers, however, and the Government are fully equal to the emergency as it affects this country. The closure of the stock and produce exchanges throughout the country, the preparation to issue emergency currency under the Aldrich-Vreeland act, the placing of clearing houses on a certificate basis and the enforcement in some States of the sixty-day-notice clause for withdrawals of savings deposits will all tend to prevent the panic which, with the absence of these measures, would undoubtedly ensue. A temporary curtailment of export trade, with its stimulating effect, must be expected; but even with Great Britain in the conflict naval strategists feel that the ocean lanes will be kept open, enabling us to dispose of our farm products, with which we are now unusually well supplied. There is every reason, therefore, for citizens of the United States to remain calm. No other country is so well prepared to meet the emergency. In a short time, probably, things will assume a settled condition and business will proceed almost as briskly as though there were no unusual disturbance abroad. There is ample cause for gratification, therefore, at the favorable situation of the Union in so terrible a season.—*The Engineering Record*, New York, August 8th, 1914.

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The calm and steady way in which London—speaking principally for the City and its financial organizations—has withstood the shock of the crisis is rational ground for assuming that no new alarm is likely further to unsettle it. The people who are laying in supplies of flour, of sugar, of condensed milk and so on, are in a large minority. Prices will rise, have already done so, in fact: but they are not likely to advance exorbitantly. Out of the evil, good will come. Canada and the United States, for example, may find their financial salvation by reason of the present grave condition of affairs. Afterwards there will arise such activity in trade, in metals, in stocks and shares as few can remember. These, however, are for the future. The immediate outlook is too serious to be illumined by more than hope, but that hope is fortified and cheered by the steadfast way in which the financial institutions of the City of London, and the people whom they affect, have met a situation that might have precipitated a panic which nobody could have called surprising.—*The Electrical Review*, London, August 7th, 1914.

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One of the most certain results of a great European war will be a world-wide scarcity of investment capital and a consequent rise in the ruling rate of interest. Indeed, such a rise has already taken place, partly as a result of the wars fought during the last dozen years and even more of the preparations for war on an enormous scale which the European nations have made. About the close of the 19th century, prior to the Boer War in South Africa and the Spanish-American war, the market value of investment funds in the highest-class securities was not far from 3 per cent. During the past year or more the average price has been probably 4 to 4½ per cent. Where the price of capital will go to in the event of a general European war, long continued, can only be conjectured. Such a war would destroy to a large extent the great reservoirs of investment capital in the principal European nations, to which all the rest of the world has resorted for the funds with which to carry on economic and industrial development. It may easily be that a year hence 5 per cent. or 6 per cent. or even 7 per cent. may be the ruling price for investment funds of the highest class. The rate on funds invested in ordinary enterprises, involving more or less risk, such as attaches to almost every private enterprise, must, of course, be correspondingly higher.

The far-reaching results of such a change in the value of capital it is impossible to foresee in full detail. It would have, of course, a vast effect upon the prices of commodities of every sort and of real estate. It will greatly limit the carrying out of works of permanent improvement, in which engineers are so largely concerned, since capital will be difficult to obtain and can only be secured at a high price. It will mean the cancellation of a great number of new enterprises because the reservoirs of capital that were to have sustained them will be dried up.

Of especial interest to many engineers is the question, What is to be done concerning the half-dozen great international engineering congresses which were scheduled for next year?

Besides the great international engineering congress to be held in San Francisco, together with numerous other international congresses relating to many branches of science and industry arranged for there, the International Railway Congress was to assemble next year at Berlin, the International Society for Testing Materials at St. Petersburg, the International Navigation Congress at Stockholm, and the Congress of Mining and Metallurgy at London. Doubtless all these congresses will have to be indefinitely postponed. It has been suggested that the American engineers might offer to welcome these various congresses in the United States. But even if it were attempted to hold the meetings here, the attempt could hardly result otherwise than in failure. With the great nations of the world at each other's throats, it is not to be expected that their representatives, many of them government officials, could be brought together in peaceful and friendly conference only a few months hence. Indeed, who is wise enough to foresee the profound changes in nations, in politics, in policies, in races, which may grow out of this terrific conflict? It sounds like a mockery, the circular before us regarding an international exhibition of art and civilization to be held at Dusseldorf next year. But that is only one of

several such international events, including our own great exposition at San Francisco, which must be either abandoned, or, if held, must do without exhibits from the chief industrial nations of Europe.

The best that may be hoped from the present terrible conflict is that when it is ended by peace, it may be a peace accompanied by universal disarmament, a peace that shall relieve the nations from those crushing burdens of preparation for war and leave them free to solve those problems of social readjustment which are the pressing problems of this century.—*The Engineering News*, New York, August 6th, 1914.

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Whilst the engineer gives place to none in the detestation of war and in efforts to avert it, to him it has an interest which it cannot have for the layman. The engineer was originally a soldier, the maker and destroyer of fortresses, the maker and user of cannons, and to him war has never meant merely the victory and defeat of opposing armies. With philosophic detachment he sees it as a scientific test of painfully wrought theories, of new materials and new offensive and defensive engines. Time has not lessened but greatly increased his influence on the art of war. Even in the short interval that has elapsed since the South African campaign he has given to the Army and Navy many new things, and if he could stand wholly apart from the horrors of the gigantic conflict with which he is now face to face he would look on the trials to which the material he has devised and made is to be put with an interest as lively and as dispassionate as that of the astronomer who seizes the rare eclipses of the sun to test his theories and new apparatus.

So far our great ships of war have had no chance of showing what value is to be placed on new designs, but now that war is declared we shall learn if the lessons of the proving ground and the theories of the study are well founded. We shall know at last if the gun is really better than the armor; we shall learn if the $13\frac{1}{2}$-in. gun is indeed superior to the 12-in.; we shall learn if the 4-in. quick-firer is efficient to ward off the attacks of destroyers. The problem of the submarine will be solved. Whether she is really as dangerous as the subtlety and secrecy of her attack have led us to suppose will be found out. We shall discover, too, if the torpedo itself is as formidable as it seems, and whether the immense improvements in it, which it owes to the engineer, have really made it the most fearful and deadly of naval arms. It is possible, too, that the greatest of all naval problems may be set at rest. Perchance some pre-Dreadnought ships may find themselves in conflict with the latest warships of the world, and we shall discover if the theory of the all-big-gun ship is well founded. Amongst other works of the engineer that will be put to the test of war between first-rate Powers the turbine must be mentioned. Whether it will endure the rough handling as well as the old reciprocating engines, whether it will be as faithful and dependable in its duty, is a question the answer to which all Admiralties and all engineers await with anxiety. Whilst the test of naval material of war is still in doubt, land material is already undergoing probation. Here the engineer has a host of new things to watch with interest. Our war in South Africa taught us many things about field artillery, and those lessons have been embodied in our 18-lb. field piece, which we believe is better than any in the world, though the new French field gun, a mysterious weapon about which little is known, may be superior to it. It is believed that the Germans, just as they have remained true to a smaller calibre naval gun, have also adhered to a smaller field gun; it is reported to throw a 15-lb. shell. Whether it makes up in muzzle velocity for what it lacks in weight remains to be seen. But it is not only in the guns themselves, but in their carriages, that much that is new has to run the gauntlet of war. The old form of carriage that recoiled with the gun is now a thing of the past. The modern field gun-carriage is an elaborate structure with recoil cylinders and running-out springs. The gun runs back with but little movement of the carriage and the rapidity of fire is greatly increased. No one yet knows what effect such a highly developed weapon may have upon the issue of a battle. Again, mechanical transport is almost a new thing which has hardly been tested on the actual theatre of a war on a large scale. Many excellences must be developed, many faults found. Those who are responsible for its design, no less than the engineers all over Europe, who have carried out the desiderata of their war offices, can hope for nothing better than that it should not be found wanting under the crucial test. Coming to still greater novelties, we have to learn how the aeroplane and seaplane comport themselves, whilst the value of the airship must be decided once and for all. With the purely military value of aeronautics the engineer is but little concerned. Whether the fact that the enemy can watch from the sky every step an army makes and report it by wireless telegraphy to headquarters, is to cause, as some aver, a great modification of tactics, is a matter of secondary importance to him from the professional standpoint. What he does want to know is that the machines he has developed with such infinite trouble and at the cost of many brave lives are capable of performing trustworthily the duties assigned to them. He has brought into war a new factor of enormous moment—a factor of which many in England think we have been too slow to take advantage of.

Besides the few obvious things we have mentioned, there are hundreds of others in which the engineer is directly interested. Every ship is full of small items which change with every new vessel as some new invention or development of an old one is brought forward. Take, for example, the range finder, of which the accuracy is now so great that it will tell the distance of an object correct within 25 yards in 10,000; the new uses to which electricity has been put; the development of wireless signalling; the new system of laying mines, and so on and so on. On every side the hand of the engineer is seen, and no one in Europe will watch the progress of arms in the greatest conflict the world has ever seen with more keenness than he.—*The Engineer*, London, August 6th, 1914.

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Municipal bonds have naturally felt the effect of the war in Europe, along with all other securities. During the first six days of this month ten or more cities received no bids for bonds offered and two thought it advisable to postpone advertised sales. But this is not to be wondered at nor should cities become alarmed thereby as to their future finances. During July the market for municipal bonds was better than ever, many selling on a basis of 3.71 per cent. to 4.40 per cent.; and the war situation can certainly have no effect on the stability of the finances of United States cities.

Railroad and industrial securities might be affected in their actual as well as their market value by the effect of the war upon commerce; but the only effect upon municipal bonds would seem to be the general withdrawal of money from investment, and this will be but temporary, in the judgment of financiers. When money

again seeks investments, in a few days or weeks, the municipals will, it would seem, be still more favorably considered than during the past few months.

We advise cities, therefore, not to rashly close down work or postpone projects indefinitely, thus throwing many citizens out of employment, but to act on the assumption that in a very few weeks they can raise money on terms at least as favorable as a year ago and possibly as those of this spring. On the other hand, however, every effort should be made to avoid selling at high rates of interest long-term bonds which will commit the city to the payment of such interest for many years to come. —*Municipal Journal*, New York, August 13th, 1914.

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The forces of war are powerful, with their perfection of death-dealing mechanisms and their high development of strategical plans for circumventing the enemy. But the present-day forces of peace—the forces of commerce, of education, of brotherhood, of mutual tolerance and good feeling—are still more powerful, and will, we are confident, prevail before too many lives have been lost or too much of the material prosperity of the belligerent peoples has been destroyed.

It has been one of the incongruities of the recent upheaval that some of the delegates to a peace conference in one of the European countries had to turn back home because of the beginnings of war. But this incident is worthy of more than a grim smile. The feelings which prompted the calling of the peace conference are still in the breasts of the people and will demand a cessation of hostilities.

While most of the nations of the world are, from a military standpoint, better prepared for war than they ever were before, these same war organizations are considered by the rank and file of citizens as relics of a former age. The organization of present-day governments is very little along the lines of offensive and defensive warfare, and very much along the lines of building up peaceful lines of industry for the welfare of their citizens. The nations of the world are on a far-reaching, interdependent commercial basis which will not long brook the interference of war.

The present has been accused of being a severely commercial age; but in a crisis of this kind it is this strong commercial tendency which will prove one of our bulwarks of safety and will insist on a speedy return to a peace basis.

From the standpoint of the contractors' interests, we are sufficiently optimistic to believe that the first scare is the worst, and that business can very rapidly get back on to a most satisfactory basis. It is true that some municipal bonds have not found ready buyers within the past few days; but capital will gradually come out from under cover as it sees business assuming its normal aspect, and will be ready to finance legitimate enterprises as usual. The dealer in machinery and equipment, too, will find that an even greater export market has been opened up to him.—*The Contractor*, Chicago, August 15th, 1914.

An increase of 125,732 tons in the unfilled orders on the books of the United States Steel Corporation was reported in the corporation's monthly statement issued at New York on August 10. This is the fourth month in which increases in the unfilled tonnage have been reported after the long period of almost uninterrupted decline in unfilled orders, which began in January, 1913. The orders now on the books of the Steel Corporation amount to 4,158,589 tons, compared with 3,998,160 at the end of May. A year ago at this time the Corporation's unfilled contracts amounted to 5,959,079 tons.

UNITED STATES COAL OUTPUT IN 1913.

According to a statement recently issued by the United States Geological Survey, based upon figures compiled by Dr. Edward W. Parker, the production of coal in the United States during 1913 was the highest on record, the total being 570,048,125 net tons (2,000 lbs.). This shows an increase of 35,581,545 net tons, or nearly 7 per cent., on the output of the previous year. It is considerably more than double the output of 1900, and more than eight times the production of 1880. The value of the coal mined in 1913 is stated at $760,488,785, as compared with $695,606,071 in 1912. The increased activity indicated by these figures was well distributed throughout the 29 coal-producing States, 23 of which showed increases and only 6 decreased production, the decrease in one of these, Colorado, being due solely to labor troubles. Twelve of the States showing increases made record yields.

Pennsylvania mined more coal in 1913, both anthracite and bituminous, than in any previous year in the history of the industry. The production reached the total of 265,306,139 net tons, valued at the mines at $388,220,933, and which is one-fifth of the world's output. Of this 91,524,927 tons were anthracite, valued at $195,181,127, and 173,781,217 tons were bituminous, valued at $193,039,806. The total tonnage broke the previous record for 1912 by 19,079,053 net tons, or nearly 8 per cent., the proportionate increase being about the same for both anthracite and bituminous. The gain in the value of anthracite, however, was $17,558,501, or about 10 per cent., over 1912, and in bituminous coal $23,669,309, or 14 per cent. The total gain over 1912 was $41,227,810, or nearly 12 per cent.

STEEL PLANT CLOSING.

Relative to the closing of the Dominion Steel plant at Sydney, N.S., an official of the company stated that the action was taken due to the stop to all industrial activity caused by the war. The Steel company has its yards full of wholly or partly manufactured material. It has 20,000 tons of rails which cannot be delivered. On the whole the company has well over two million dollars' worth of material unsold, or sold and not yet delivered. With regard to the order for 10,000 tons of rails recently received by the company, the specifications would involve starting up a blast furnace; and the order would only give work for a short time. It seemed better to hold this order as a nucleus until others can be added to it, so as to make work, when begun, fairly continuous. There is business in sight for bar steel to keep the mill running for some little time. The officials hope that it will not be many weeks before they will have enough business to justify recommencing in such a way as to keep running for a reasonable time.

The output of the Dominion Coal Company, Glace Bay, N.S., for June, 1914, amounted to 452,270 tons, which is to be compared with the largest previous output of 438,272 tons produced in October, 1913. It is stated, moreover, that the output for June would have been 50,000 tons greater, had it been possible to work the mines to full capacity. The production of the Dominion Coal Company for the first half of 1914 was 2,254,043 tons from the Glace Bay mines and 199,961 from the Springhill mines, comparing with 2,295,082 tons from Glace Bay and 193,797 from Springhill in the first half of 1913. There is, therefore, only a difference of 34,000 tons between the two half-years.

A High Surge-Tank.—A surge-tank on the differential principle has been constructed at the hydro-electric plant of the Salmon River Power Company, Altmar, N.Y. The structure is 180 feet high to the top edge of the tank, which has a height of 80 feet and a diameter of 50 feet, and stands on a base built up of ten lattice columns. The tank has to take care of surges from a column of water 9,625 feet long and 12 feet in diameter. A 12-foot riser connects the bowl-shaped bottom of the tank with the pipe-line. Inside the tank is a 10-foot vertical pipe tapered from 10 feet 8 inches diameter at the bottom end to 15 feet at the upper end. The annular space between the mouth of the 12-foot riser and that of the 10-foot 8-inch pipe allows part of the water to flow straight out into the tank, while the rest passes up the 10-foot pipe. The effect is to throttle the surges very considerably.

ELECTRIFICATION OF THE BUTTE, ANACONDA AND PACIFIC RAILWAY.

THE Butte, Anaconda and Pacific Railway has been entirely under electrical operation for the past six months. The installation is most interesting everywhere as it marks a new departure in electrification. Prior to it, railway electrification for the most part was influenced largely by the demand for rapid suburban and interurban service, by the frequency of that service and by other considerations, such as smoke abatement in cities. The above electrification is the first on record however, to have been made for the express purpose of securing greater economy. Further, as the first road to use 2,400-volt direct current, it is likewise worthy of note.

The first electric locomotives were put in service about June 1, 1913, and set to hauling ore. By January 1, 1914, according to information furnished by the General Electric Company, they had hauled nearly 2½ million tons of ore and had travelled approximately 201,000 miles. The change from steam to electric haulage was made without any change in the personnel of the train crews and without any delays or alterations in the schedule.

Prior to the installation, the Butte, Anaconda and Pacific Railway was a single track main line about 30 miles in length with about 85 miles of sidings, yards, etc. There is a maximum grade of 0.3% against loaded cars and of 1% against empties. The heaviest train has been 50 loaded ore cars, approximately 3,400 tons. The line extends from Butte, where connection is made with several trunk lines to Anaconda, and is the only rail outlet for the latter city. The ore traffic between the two cities is considerable, as is evidenced by the above figures of the first seven months of operation. The smelters are situated in Anaconda while the ore mines are in or near Butte. Fig. 1 illustrates the location of the electrified system and the relative situation of the two cities.

Energy for the operation of the system is obtained from Great Falls, Montana, which has for some time been supplying electrical power for the operation of the mines and smelting plants in the above cities. The power plant consists of six hydro-electric units with a nominal rated capacity of 21,000 kw. The current generated is of 66,000 volts, 60 cycles, 3-phase. It is transmitted at 102,000 volts over a distance of 130 miles by two parallel lines to the sub-station at Butte. Another transmission line carries power at 60,000 volts to the Anaconda sub-station, 26 miles distant. These two sub-stations are equipped with 2,400-volt motor-generators. Each set consists of a 3-phase, 60-cycle, 720 r.p.m. synchronous motor direct connected to two 500-kw., 1,200-volt direct connected generators arranged to operate in series for 2,400 volts.

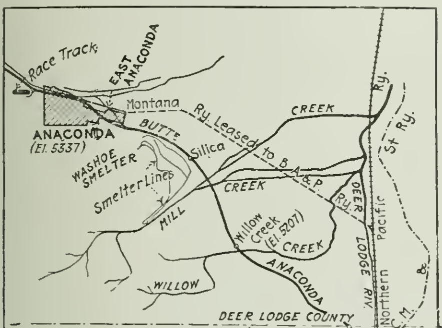
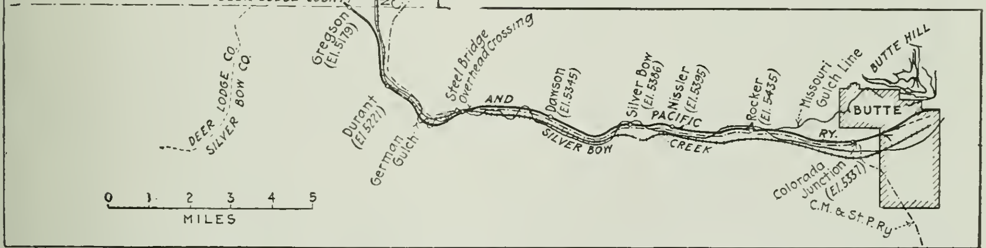



Fig. 1.—Route of the Butte, Anaconda and Pacific Railway.

Fig. 2.—One of the 2,400-volt Direct Current Freight Locomotives.

The overhead construction was especially designed to give the flexibility necessary for the satisfactory operation of the pantograph trolley used on the locomotives. The trolley used over all tracks is of copper and is supported by an 11-point catenary suspension from a stranded steel messenger cable. The trolley wire is reinforced between the sub-stations with two copper cables tapped to the trolley at intervals of 1,000 ft. The rails are connected by No. 0000 bonds at every joint.

The locomotive equipment consists of seventeen 80-ton units, two for passenger service and fifteen for freight. The ore trains are being hauled by two coupled units. The locomotives are of an articulated double-

truck type, with all the weight on the drivers. The double unit, 160-ton locomotives for freight purposes are capable

Fig. 3.—Ore Train, Hauled by One of the Two-Locomotive Units.

of giving a continuous sustained output of 2,100 h.p. and have a free-running speed of 35 miles per hour. They are geared for slow speed also. The passenger locomotives, on the other hand, are geared for a free-running speed of 55 miles per hour, or 45 miles per hour with three passenger cars. Curves as sharp as 20° occur on portions of the line, although the average curvature is from 6° to 10°. The locomotives are designed with sufficient flexibility to operate on a curve of 31° at slow speed.

The following information respecting the construction of the locomotives may be of interest:

Length inside of knuckles	37 ft. 4 in.
Length over cab	31 ft.
Height over cab	12 ft. 10 in.
Height with trolley down	15 ft. 6 in.
Width over all	10 ft.
Total wheel base	26 ft.
Rigid wheel base	8 ft. 8 in.
Track gauge	4 ft. 8½ in.
Total weight	160,000 lb.
Weight per axle	40,000 lb.
Wheels, steel tired	46 in.
Journals	6 x 13 in.
Gears, forged rims, freight locomotives	87 teeth
Gears, forged rims, passenger locomotives	80 teeth
Pinions, forged, freight locomotives	18 teeth
Pinions, forged, passenger locomotives	25 teeth
Tractive effort at 30% coefficient	48,000 lb.
Tractive effort, at one hour rating	30,000 lb.
Tractive effort at continuous rating	25,000 lb.

Fig. 4 shows the general design of a separate tractor truck recently added to the equipment and to be used in conjunction with the electric locomotives.

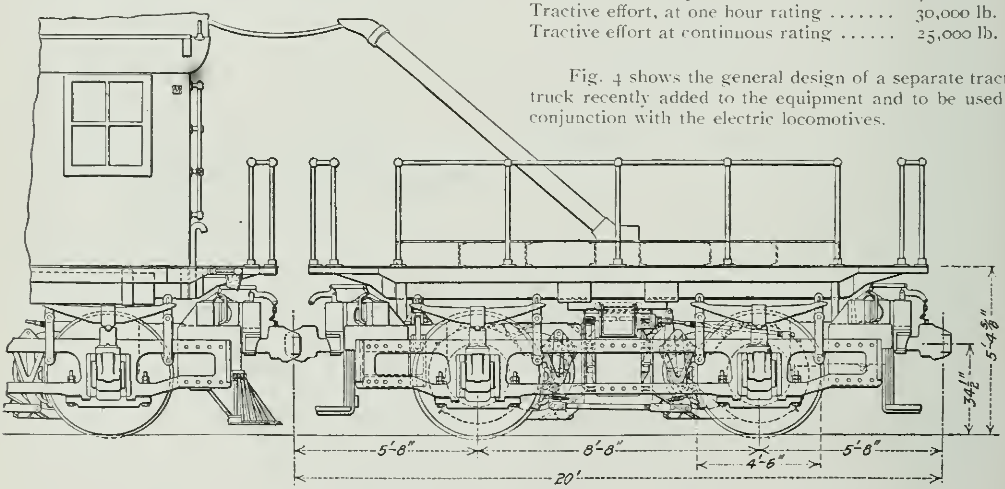


Fig. 4.—Separate Tractor Truck, for Use with Electric Locomotive.

RAILROAD SLEEPERS FOR SCOTLAND.

In view of the fact that an increased and more direct steamship service is anticipated between British Columbia and Glasgow, when the Panama canal is open, the Glasgow authorities have announced what specifications are required for railroad sleepers, or ties, in that market. At present the trade is for the most part with the Baltic for sleepers made from what is known as red wood.

The blocks from which the sleepers are to be cut should be of good sound timber, straight, free from shakes, large or loose knots, or other blemishes, and reasonably free from sapwood, water and dirt.

The sleepers should be cut from blocks not less than 8 feet 11 inches long, each block being sawn up the middle so as to form two sleepers. The blocks should be of such transverse dimensions that at least 90 per cent. of the sleepers shall be, after sawing, 10 inches broad and not less than 4⅞ inches thick, with a flat surface on the upper side not less than 7 inches in width throughout the entire length of the sleeper. The remainder, which must not exceed 10 per cent. of the total quantity, should be, after sawing, 10 inches broad, and not less than 4¾ inches thick, with a flat surface on the upper side not less than 6½ inches in width throughout the entire length of the sleeper.

The sleepers should be accurately gauged, and all those which do not comply with the requirements specified above should be rejected. Some buyers do the sawing of the blocks in Glasgow. Other details would be a matter of correspondence between buyer and seller.

SURGE TANK PROBLEMS III.

ANALYSIS AND GRAPHICAL REPRESENTATION OF PROBLEMS DUE TO CONDITIONS OF VARYING OUTFLOW TO PARTIAL OR COMPLETE SHUT-DOWN OR OPENING.

By PROF. FRANZ PRASIL.

Authorized Translation by E. R. Weinmann and D. R. Cooper, Hydraulic Engineers, New York City.

Case C.—Variable Outflow.

In the following, we consider first the influence of a gradual shut-down and opening of the penstock, and secondly the case when the outflow is variable with respect to time. The movement during the period of a gradual shut-down will be quite different from that after the shut-down. Therefore, we must consider both cases separately.

(1) Movement During the Shut-down.—We assume that the closing occurs so that the outflow decreases in direct proportion to the time which is expressed by the formula:

$$q = Q_1\left(1 - \frac{t}{\mathrm{T}}\right) \quad (56); \quad \mathrm{T} = \text{time for complete shut-down}$$

Therefore,

$$c = c_1\left(1 - \frac{t}{\mathrm{T}}\right) \qquad \frac{dc}{dt} = -\frac{c_1}{\mathrm{T}}$$

Similar to equation (23) we get the special principal equation (57) in the following form:

$$\frac{d^2z}{dt^2} + \frac{1}{T_0}\cdot\frac{dz}{dt} + \frac{z}{T^2} + \frac{c_1}{T_0}\left(1 - \frac{t}{\mathrm{T}}\right) - \frac{c_1}{\mathrm{T}} = 0 \quad (57)$$

The general integral of this equation may be obtained by means of the theory of linear differential equations of the second order.

The general member is $z_1 = R\,e^{-\frac{t}{2T_0}} \sin\left(\beta + \frac{t}{T_1}\right)$

The particular integral $z_2 = b_1 + b_2 . t$ when b_1 and b_2 may be determined by inserting the value of z_2, also $\frac{dz}{dt} = b_2$ and $\frac{d^2z}{dt^2} = 0$ in equation 57.

Therefore,

$$\frac{b_2}{T_0} + \frac{b_1}{T^2} + \frac{b_2 t}{T^2} + \frac{c_1}{T_0} - \frac{c_1 t}{T_0 \mathrm{T}} - \frac{c_1}{\mathrm{T}} = 0 \quad (58)$$

As the conditions of this equation must be fulfilled for all values of t the two equations follow:

$$\frac{b_2}{T_0} + \frac{b_1}{T^2} + \frac{c_1}{T_0} - \frac{c_1}{\mathrm{T}} = 0; \quad \frac{b_2}{T^2} - \frac{c_1}{T_0 \mathrm{T}} = 0 \quad (59)$$

$$\text{As } h_1 = \frac{c_1 T^2}{T_0} \qquad b_1 = h_1\left[\frac{T_0}{\mathrm{T}}\left(1 - \frac{T^2}{T_0^2}\right) - 1\right] \qquad b_2 = \frac{h_1}{\mathrm{T}}$$

The general integral is obtained by the form $z = z_1 + z_2$.

Therefore,

$$z = R.e^{-t/2T_0} \sin(\beta + t/T_1) + b_1 + b_2 t \quad (60)$$

And with differentiation with respect to t $\left(tg\,\gamma = \frac{2T_0}{T_1}\right)$

$$s = \frac{R}{T} e^{-t/2T_0} \sin(\gamma - \beta - t/T_1) + b_2 \quad (61)$$

In order to obtain the constant for the integration, consider that for $t = 0$, $z = z_0 = -h_1$, as in case (A), but that $s = s_0 = 0$, because the shut-down occurs gradually. Therefore:

$$R \sin\beta = -h_1 \frac{T_0}{\mathrm{T}}\left[1 - \frac{T^2}{T_0^2}\right]$$

$$R \cos\beta = -h_1 \frac{T_1}{2\mathrm{T}}\left[3 - \frac{T^2}{T_0^2}\right]$$

$$R = h_1 . \frac{T_0}{\mathrm{T}} . \frac{T_1}{T} \quad (62) \qquad tg\,\beta = 2\,\frac{1 - \frac{T^2}{T_0^2}}{3 - \frac{T^2}{T_0^2}} . \frac{T_0}{T_1} \quad (63)$$

For the graphical demonstration of these functions we may separate them into three equations. For instance, the z — function into

$$r = R\,e^{-t/2T_0\,\phi}; \quad z_1 = r \sin(\beta + \phi); \quad z_2 = b_1 + (b_2 T_1)\phi. \quad (64)$$

The value of r determines again a logarithmic spiral with the slope $tg\,\alpha = -\frac{T_1}{2T_0}$ with the initial vectors r_0 and β.

z_1 is obtained in the rectangular co-ordinate system by projection from the polar system as in the former cases. z_2 in the same rectangular co-ordinate system is a straight line which intersects the ordinate axis at the distance b_1 from the initial point and whose inclination to the axis of abscissæ is fixed by the direction constant $b_2 . T_1$. The algebraic sum of $z_1 + z_2$ gives z. (See Fig. 5.) But only that part of the curve which lies between the values of the abscissæ 0 and T is of practical importance because at the time T the complete shut-down has already occurred (as we assumed).

(2) Movement After Completed Shut-down.—After the shut-down has occurred, the movement of the water

surface continues as described in case (A). Therefore, from this moment the following equations are effective:

$$z = R_1 e^{-t/2T_0} \sin(\beta_1 + t/T_1) \qquad (65)$$

$$s = \frac{R_1}{T} e^{-t/2T_0} \sin(\gamma - \beta_1 - t/T_1) \qquad (66)$$ (see equations 32 and 35).

$$R_1 \sin \beta_1 = z_T$$

$$R_1 \cos \beta_1 = \left(s_T + \frac{z_T}{2\,T_0}\right)$$

where z_T and s_T are limiting values of the first period.

The demonstration of the movement may be developed according to the same method as in case (A). For the computation of the value of the most practical importance (the maximum elevation), we get

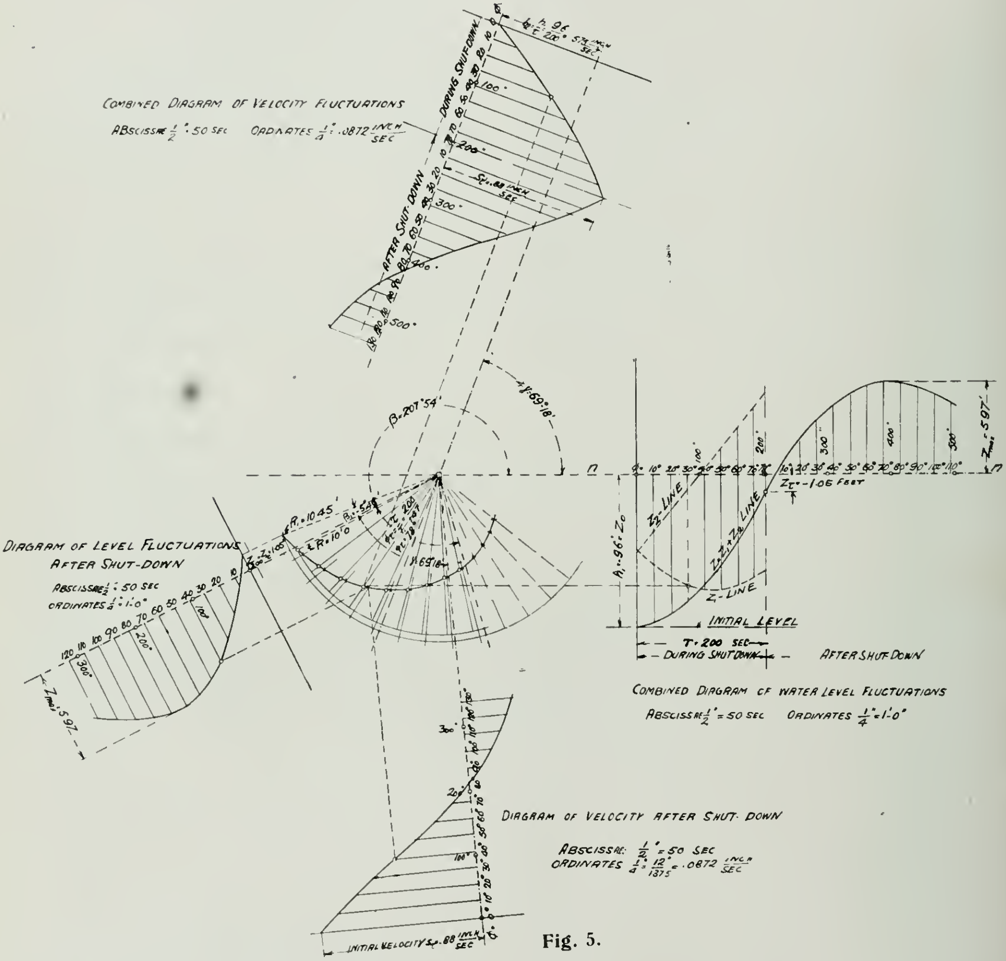


Fig. 5.

Where $tg\ \gamma = \dfrac{2\,T_0}{T_1}$

The constants R_1 and β_1 have to be determined from the value of z and s computed for $t = \text{T}$. In order to obtain an easier computation, we measure the time for the second period from the moment of the completed shutdown, so that the following equations for the determination of the constants R_1 and β_1 are in effect:

$$z \max = R_1 e^{-\frac{T_1}{2\,T_0}(\gamma - \beta_1)} \sin \gamma \qquad (67)$$

(3) Practical Example.—The computation in connection with the preceding example follows for a shutdown in 10, 100 and 200 seconds, with a discharge of 530 cubic feet per second.

With $T = 137.5$ seconds, $T_0 = 194.5$ seconds, $T_1 = 147$ seconds, $h_1 = 9.6$ feet, we get the following table:

for τ =	10 sec.	100 sec.	200 sec.
$b_1 = h_1 \left[\frac{T_0}{\tau}\left(1 - \frac{T^2}{T_0^2}\right) - 1\right] =$	+83.3 feet	—.264 feet	— 4.93 feet
$b_2 = \frac{h_1}{\tau} =$	.96 $\frac{\text{feet}}{\text{sec.}}$	.096 $\frac{\text{feet}}{\text{sec.}}$	.048 $\frac{\text{feet}}{\text{sec.}}$
$R = h_1 \cdot \frac{T_0}{\tau} \cdot \frac{T_1}{T} =$	200 feet	20 feet	10 feet
$tg\beta = \dfrac{2\left(1 - \frac{T^2}{T_0^2}\right) T_0}{\left(3 - \frac{T^2}{T_0^2}\right) T_1} =$	.530	.530	.530
	$\beta = 207° 54'$	arc $\beta = 3.628$	$\gamma = 69° 18'$; arc $\gamma = 1.210$
z_τ =	—9.10 feet	—4.85 feet	—1.05 feet
s_τ =	.097 $\frac{\text{feet}}{\text{sec.}}$	.091 $\frac{\text{feet}}{\text{sec.}}$	.0735 $\frac{\text{feet}}{\text{sec.}}$
$R_1 \sin \beta_1$ =	—9.10 feet	—4.85 feet	—1.05 feet
$R_1 \cos \beta_1$ =	+11.05 feet	+11.6 feet	+10.4 feet
R_1 =	14.30 feet	12.55 feet	10.45 feet
β_1 negative =	—39° 30′	—22° 44′	—5° 46′
arc β_1 =	—.6894	—.3968	—.1006
z max =	+6.53 feet	+6.40 feet	+5.97 feet

From the graphical demonstration (Fig. 4)* we see that the period of shut-down up to 100 seconds influences the maximum elevation a very small amount indeed. The explanation for this is that during this period the velocity of flow in the main conduit decreases very little. For the determination of the dimensions of the surge tank, we have, therefore, to consider the results of the limiting case, that is, the sudden shut-down. The computation for that condition is a much simpler one, (case *A*). For a gradual opening, the same relations exist. The lowering of the level $n - n$ occurs to the same extent and for the same duration as the rise above the initial level in the case already computed.

Of special interest is the case of an outflow, which is variable in the sense that the outflow increases considerably during a certain time and decreases afterwards to the same amount as before or to some other amount, (for instance, in a plant for railway operation).

1. Analytical Investigation.—We assume now, that under circumstances similar to those above mentioned, the following law of outflow is effective:

$$q = \epsilon . Q_1 (1 + f \sin t/\tau)$$

so that for the time

$$t = o; \quad t = \frac{\pi.\tau}{2}; \quad t = \pi\tau \quad q \text{ becomes resp.} = \epsilon Q_1;$$

$$\epsilon Q_1 (1 + f); \quad \epsilon Q_1 \qquad (68)$$

after the time $t = \pi.\tau$ the outflow may be constant again. ϵ and f are natural numbers. f is the proportion of the maximum increase of the outflow to the normal outflow. So that

$$c = \frac{q}{A} = \epsilon c_1 \left(1 + f \sin \frac{t}{\tau}\right) \qquad \frac{dc}{dt} = \epsilon . f . \frac{c_1}{\tau} \cos \frac{t}{\tau}$$

Equation 23 may then be written:

$$\frac{d^2z}{dt^2} + \frac{1}{T_0} \cdot \frac{dz}{dt} + \frac{z}{T^2} + \frac{\epsilon . c_1}{T_0} + \frac{\epsilon . f . c_1}{T_0} \sin \frac{t}{\tau} + \frac{\epsilon . f . c_1}{\tau} \cos \frac{t}{\tau} = o \quad (69)$$

If we introduce

$$z = y - \frac{\epsilon c_1 T^2}{T_0} = y - \epsilon h_1; \quad \frac{dz}{dt} = \frac{dy}{dt}; \quad \frac{d^2z}{dt^2} = \frac{d^2y}{dt^2} \quad (70)$$

and further,

$$\epsilon . f . c_1 \left[\frac{1}{T_0} \sin \frac{t}{\tau} + \frac{1}{\tau} \cos \frac{t}{\tau}\right] =$$

$$\epsilon . f . c_1 \sqrt{\frac{1}{T_0^2} + \frac{1}{\tau^2}} \sin \left(\phi + \frac{t}{\tau}\right) \quad (71)$$

with $tg\,\phi = \frac{T_0}{\tau}$ then the equation 69 transposes to

$$\frac{d^2y}{dt^2} + \frac{1}{T_0} \frac{dy}{dt} + \frac{y}{T^2} +$$

$$\epsilon . f . c_1 \sqrt{\frac{1}{T_0^2} + \frac{1}{\tau^2}} \sin \left(\phi + \frac{t}{\tau}\right) = o \quad (72)$$

*See *The Canadian Engineer* August 27th, Page 370.

and it then follows again from the theory of differential equations of the second order that $y = y_1 + y_2$, that is,

$$y_1 = R.e^{-\frac{t}{2T_0}} \sin(\beta + t/T_1) \quad \text{general integral} \quad (73)$$

$$y_2 = b \sin\left(\psi + \frac{t}{\mathrm{T}}\right) \quad \text{particular integral} \quad (73)$$

The latter may also be written

$$y_2 = b.\sin\psi\cos\frac{t}{\mathrm{T}} + b\cos\psi\sin\frac{t}{\mathrm{T}} \quad (74)$$

The integration constants R and β may be obtained from the initial phase and the constants b and ψ by forming the equations

$$\frac{dy_2}{dt} = \frac{b}{\mathrm{T}}\cos\left(\psi+\frac{t}{\mathrm{T}}\right) = \frac{b}{\mathrm{T}}\cos\psi\cos\frac{t}{\mathrm{T}} - \frac{b}{\mathrm{T}}\sin\psi\sin\frac{t}{\mathrm{T}}$$

$$\frac{d^2y_2}{dt^2} = -\frac{b}{\mathrm{T}^2}\sin\left(\psi+\frac{t}{\mathrm{T}}\right) = -\frac{b}{\mathrm{T}^2}\sin\psi\cos\frac{t}{\mathrm{T}} - \frac{b}{\mathrm{T}^2}\cos\psi\sin\frac{t}{\mathrm{T}}$$

We then introduce these values in the differential equation and combine the members containing cos t/T and sin t/T

$$\left[-\frac{b}{\mathrm{T}^2}\sin\psi + \frac{b}{\mathrm{T}T_0}\cos\psi + \frac{b}{T^2}\sin\psi + \epsilon.f.c_1\sqrt{\frac{1}{T_0^2}+\frac{1}{\mathrm{T}^2}}.\sin\phi\right]\cos\frac{t}{\mathrm{T}} +$$

$$\left[-\frac{b}{\mathrm{T}^2}\cos\psi - \frac{b}{\mathrm{T}T_0}\sin\psi + \frac{b}{T^2}\cos\psi + \epsilon.f.c_1\sqrt{\frac{1}{T_0^2}+\frac{1}{\mathrm{T}^2}}.\cos\phi\right]\sin\frac{t}{\mathrm{T}} = o$$

and as these equations hold good for all values of t, the terms in both parentheses must become o. One thus obtains two equations with the unknowns b and ψ and considering that $tg\,\phi = \frac{T_0}{\mathrm{T}}$ and $h_1 = \frac{c_1 T^2}{T_0}$, it follows

$$b = -\epsilon.f.h_1 \frac{\sqrt{1+\frac{T_0^2}{\mathrm{T}^2}\left[\frac{T^2}{\mathrm{T}^2}+\frac{T^2}{T_0^2}-1\right]^2}}{1+\frac{T^2}{\mathrm{T}^2}\left[\frac{T^2}{\mathrm{T}^2}+\frac{T^2}{T_0^2}-2\right]}$$

$$tg\,\psi = -\frac{T_0}{\mathrm{T}}.\left[\frac{T^2}{\mathrm{T}^2}+\frac{T^2}{T_0^2}-1\right] \quad (75)$$

For the determination of the integration constants R and β, it must be considered that for

$$t = o;\quad z = -\epsilon h_1;\quad y = o;\quad s = o.$$

We obtain for this case the equations

$$R.\sin\beta = -b.\sin\psi$$

$$R.\cos\beta = -b\left[\frac{T_1}{\mathrm{T}}\cos\psi + \frac{T_1}{2T_0}\sin\psi\right] \quad (76)$$

During the variation of the outflow the following equations are effective:

$$z = \epsilon.h_1 + Re^{-\frac{t}{2T_0}}\sin\left(\beta+\frac{t}{T_1}\right) + b\sin\left(\psi+\frac{t}{\mathrm{T}}\right)$$

$$s = \frac{R}{T}e^{-\frac{t}{2T_0}}\sin\left(\gamma-\beta-\frac{t}{T_1}\right) + \frac{b}{\mathrm{T}}\cos\left(\psi+\frac{t}{\mathrm{T}}\right)$$

with $tg\,\gamma = \frac{2T_0}{T_1}$

ψ amounts generally to about $\frac{3\pi}{2}$ which relation simplifies the computation of R and β.

The variation ceases (as we assumed) after the time $t = \pi.\mathrm{T}$. The values which correspond to the elevation of the water surface and velocity at that time are obtained by the formulæ:

$$z_{\mathrm{T}} = -\epsilon h_1 + Re^{-\frac{\mathrm{T}}{2T_0}}\sin\left(\beta+\pi\frac{\mathrm{T}}{T_1}\right) - b.\sin\psi$$

$$s_{\mathrm{T}} = \frac{R}{T}e^{-\frac{\mathrm{T}}{2T_0}}\sin\left(\gamma-\beta-\pi\frac{\mathrm{T}}{T_1}\right) - \frac{b}{\mathrm{T}}\cos\psi \quad (77)$$

For further investigation, the formulæ of case (A) may be applied. In order to simplify matters, in the determination of the further movement, we measure the time from the instant of the beginning of the constant outflow and logically we must use the limiting values of the preceding phase for the determination of the integration constants R_1 and β_1.

If we do not hinder the variation of the outflow but maintain the law $\epsilon Q_1\left(1+f\sin\frac{t}{\mathrm{T}}\right)$, we see that the movement of the water surface in the surge tank takes the form of a forced oscillation; where the influence of the first member decreases with the increase of t and this the quicker the larger the value of $\frac{T_1}{2T_0}$ becomes in the member

$$e^{-\frac{t}{2T_0}} = e^{-\frac{T_1}{2T_0}\cdot\frac{t}{T_1}}$$

The movement of the level of the water surface is merely that of a harmonic oscillation. In such cases it is well known that the phenomenon of resonance may occur, if the period of the actuating influence has the same duration as the swinging bodies' own period, that is to say, if, in the case mentioned $\mathrm{T} = T$. The value of the amplitude of the forced oscillation is then

$$b = -\epsilon fh_1\frac{\sqrt{1+\frac{T^2}{T_0^2}}}{T^2/T_0^2} = -\epsilon fh_1\sqrt{\frac{T^2}{\mathrm{T}^2}+1}\,.\,\frac{T_0}{\mathrm{T}} \quad (78)$$

We obtain the angle ψ from $tg\,\psi = -\dfrac{T}{T_0} = -\dfrac{1}{tg\,\varphi}$ (79)

because $\dfrac{T_0}{\tau} = tg\,\varphi$ and $\tau = T$.

According to the theory of the phenomena of resonance, the amplitude of the forced oscillation becomes of infinite value when the damping force is infinitely small. The latter would be the case, using our terms, when $T_0 =$ infinite with which value the amplitude of the above-mentioned equation also becomes infinite. The phase difference between force and movement has thereby to be equal to $\dfrac{\pi}{2}$, which also finds its expression in this equation (79).

2. Graphical Demonstration.—The graphical demonstration of the movement of the first phase is not difficult. The demonstration of the values

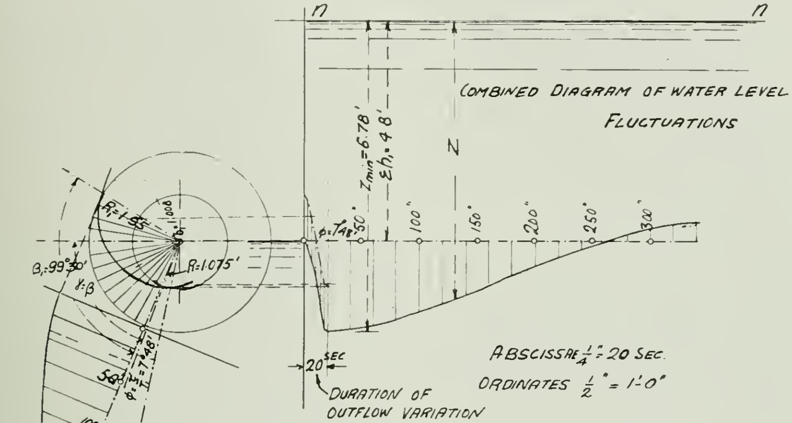
$$z_1 = R\,e^{-\frac{t}{2T_0}} \sin\left(\beta + \frac{t}{T_1}\right)$$

may be carried out in the same form as before by means of the projection of the logarithmic spiral. The demonstration of

$$z_2 = b.\sin\left(\psi + \frac{t}{\tau}\right) = b\sin\left(\psi + \frac{T_1}{\tau}\cdot\frac{t}{T_1}\right)$$

is obtained by projection of a circle, constructed with the radius b in the polar system, where the initial vector is inclined against the axis of abscissæ with an angle ψ.

In this case a rotation of the initial vector of z_1 by an amount of 2π corresponds to a rotation of the initial vector of z_2 by an amount equal to $\dfrac{T_1}{\tau}2\pi$. (See Fig. 6.)



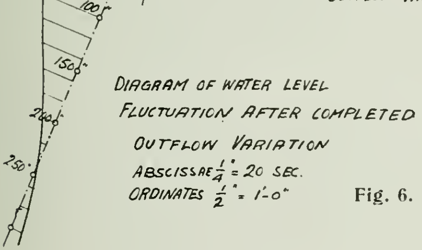


Fig. 6.

3. Analytical Example.—We use the same conduit and surge tank dimensions and assume the same friction conditions. As before, we take $\epsilon = 0.5$; with $f = 1$ and for $\tau = 20$ seconds we have an initial flow of 265 cubic feet per second which increases during the time $\dfrac{\pi}{2}.\tau = 31.4$ seconds to 530 cubic feet per second, and decreases after another period of 31.4 seconds (a total of 62.8 seconds) to 265 cubic feet per second. Therefore, with $T = 137.5$ sec. $T_0 = 194.5$ sec. $T_1 = 147$ sec. $h_1 = 9.6$ ft.

we get $\dfrac{T_0}{\tau} = 9.725$; $\dfrac{T}{\tau} = 6.875$; $\dfrac{T}{T_0} = .707$

$$b = -\epsilon f h_1 \frac{\sqrt{1 + \dfrac{T_0^2}{\tau^2}\left[\dfrac{T^2}{\tau^2} + \dfrac{T^2}{T_0^2} - 1\right]^2}}{1 + \dfrac{T^2}{\tau^2}\left[\dfrac{T^2}{\tau^2} + \dfrac{T^2}{T_0^2} - 2\right]} = -1.008 \text{ feet}$$

$$tg\,\psi = -\frac{T_0}{\tau}\left[\frac{T^2}{\tau^2} + \frac{T^2}{T_0^2} - 1\right] = -457.1$$

ψ lies in the fourth quadrant and is equal to 270° 7′ 50″, which is practically 270°. With the latter value $\sin\psi$ becomes -1 and $\cos\psi = 0$. We get

$$R\sin\beta = +b \qquad R\cos\beta = +\frac{T_1}{2T_0}$$

and therefore

$$tg\,\beta = \frac{2T_0}{T_1} = tg\,\gamma \qquad \beta = \gamma = 69° \; 18'$$

$$R = b\sqrt{1+\frac{T_1^2}{(2\,T_0)^2}} = b\,.\,T_1\sqrt{\frac{1}{T_1^2}+\frac{1}{(2\,T_0)^2}} =$$

$$b\,.\,\frac{T_1}{T} = -1.008\,.\,\frac{147}{137.5}$$

$R = -1.075$ feet, therefore

$$z = -4.8 - 1{,}075\,.\,e^{-\frac{t}{389}}\sin\left[69^\circ\ 18' + \frac{t}{147}\right] + 1.008\cos\frac{t}{20}$$

$$v = +\,.00782\,e^{-\frac{t}{389}}\sin\frac{t}{147} - .0503\sin\frac{t}{20}$$

If at the time $t = \pi.\tau$ the fluctuation of the outflow ceases it follows that

$$z_T = -4.8 - 1.075\,e^{-\frac{20}{389}\pi}\sin\left(69^\circ\ 18' + \frac{20}{147}\right) - 1.01 = 2.88\text{ ft.}$$

$$v_T = .00782\,e^{-\frac{20}{389}\pi}\sin\frac{20}{147} = .00275\text{ feet per second.}$$

For the movement that follows, we may use the equations (32) and (35)

$$z = -\epsilon h_1 + R_1\,e^{-\frac{t}{2\,T_0}}\sin\left(\beta_1 + \frac{t}{T_1}\right)$$

$$s = \frac{R_1}{T}\,e^{-\frac{t}{2\,T_0}}\sin\left(\gamma - \beta_1 - \frac{t}{T_1}\right) \quad \text{with } tg\,\gamma = \frac{2\,T_0}{T_1}$$

and R_1 and β_1 may be determined by the conditions $t = o$, $z = z_T$, $s = s_T$. We obtain

$R_1\,.\,\sin\beta_1 = -9.6 + 2.88 + 4.8 = -1.92$ feet

$R_1\,.\,\cos\beta_1 = .00275\,.\,147 - 1.92\,\frac{147}{389} = -.321$ feet

$R_1 = 1.95$ feet; β_1 lies in the third quadrant, i.e., negative.

$tg\,\beta_1 = 5.98975 \quad \beta_1 = -99^\circ\ 30' \quad \text{Arc}\,\beta_1 = -1.737$

$\gamma = 68^\circ\ 18' \quad \text{arc}\,\gamma = 1{,}210$

$$z = -4.8 + 1.95\,e^{-\frac{t}{389}}\,.\,\sin\left[-99^\circ\ 30' + \frac{t}{147}\right]$$

$$s = -.0142\,e^{-\frac{t}{389}}\,.\,\sin\left[11^\circ\ 12' + \frac{t}{147}\right]$$

Since at the time $t = o$ the velocity s is positive, a maximum first occurs. The time from the beginning of that maximum until the beginning of the second phase is $t_1 = 147\,(\gamma - \beta_1) = 433$ seconds.

$$z_1\text{ min} = -4.8 + 1.95\,e^{-\frac{433}{389}}\sin\gamma = -4.19\text{ feet}$$

The general course of the movement may be seen in Fig. 6.

In case of a continuous fluctuation of flow, expressed by the law $q = \epsilon Q_1\left(1 + f\sin\frac{t}{\tau}\right)$ with $\epsilon = .5$ and $f = 1$ the forced oscillation becomes nearly a constant harmonic oscillation of the amplitude one foot measured from $z = -4.8$ feet and for a duration of period of 137.6 seconds.

The case of resonance might occur if $\tau = T = 137.5$ seconds. This would be the case for an amplitude of the forced oscillation (measured from $z = -4.8$ feet) equal to

$$b = \pm\,\epsilon.f.h_1\sqrt{\frac{T_0^2}{\tau^2} + 1}\,.\,\frac{T_0}{T} = \pm\,11.7\text{ feet.}$$

Herein the duration of period would be $T\,.\,2\pi = 137.5\,.\,2\,.\,\pi$ sec $= 863$ sec $= 14'\ 23''$. It does not seem impossible for such periods to occur in regular operations as for railways, so that this investigation should be useful.

The preceding method, introducing a periodical function for the determination of a variable outflow in function of the time may be enlarged, introducing

$$q = \epsilon Q_1\left[f_0 + f_1\sin\left(\phi_1 + \frac{t}{\tau}\right) + f_2\sin\left(\phi_2 + 2\,\frac{t}{\tau}\right) + \ldots\right] \quad (80)$$

where we find the values for f and ϕ corresponding to a given variation of q by means of the Fourier series. The integration of the differential equation thus obtained involves no difficulty whatever. It is based upon the same method as that given in the last example. The values of z and s have the form

$$z = z_0 + R.e^{-\frac{t}{2\,T_0}}\sin\left(\beta + \frac{t}{T_1}\right) + \Sigma\,k_n\sin\left(\psi_n + n\frac{t}{\tau}\right)$$

$$(81)$$

$$s = s_0 + \frac{R}{T}\,e^{-\frac{t}{2\,T_0}}\sin\left(\gamma - \beta + \frac{t}{T_1}\right) + \Sigma\,\frac{n\,.\,s_n}{\tau}\cos\left(\psi_n + n\frac{t}{\tau}\right)$$

Naturally the computation requires great care. The graphical demonstration is obtained by superposition of the projections obtained from the polar system with the logarithmic spirals $r = R\,e^{-\frac{T_1}{2\,T_0}\cdot\frac{t}{T_1}}$ and the circles with the radii k.

(To be continued.)

Editorial

"Business as Usual"

ORDERS AND CONFIDENCE.

The opinion was expressed in these columns recently that the government authorities of Canada should do all in their power to continue public works in progress and to commence others. An announcement has come from Ottawa since then that the Dominion government will follow that policy. It is obviously sound economics. If the national machinery is stopped entirely—and the engineering profession is an important cog—only disaster can be brought upon the country. The advice given to Great Britain by a celebrated London authority is exceedingly applicable to the workers of the Dominion.

"Orders should be given," he says, "factories should be run, and everything should be arranged to maintain, as far as possible, the productive power and the income of the country.

"At such a time it is of the greatest importance that every one should endeavor to act as if great events were not impending. Were confidence seriously disturbed business would come practically to an end and our ability to face the difficulties that may be in front of us would be seriously impaired. Therefore, it is of vital importance that as far as possible, the events that are now taking place should not interfere with the daily life and the daily work of the nation.

"Every one, according to his ability, must endeavor to work hard in order that individual incomes and therefore the income of the whole nation, may be maintained at the highest possible level."

These are excellent sentiments and carried into practice will help considerably to overcome the adverse effects of war. Engineers, buyers and sellers of plant and machinery must give to the national situation at least their individual share of confidence and a share of business, even if it is somewhat reduced. To withdraw entirely both orders and confidence is inimical not only to their own interests but also to the general welfare of Canada.

THE COST OF NOISE.

Have the efficiency engineers about whose work we have heard much in recent years, given attention to the factor of noise in the engineering field and in machine plants generally? There is an enormous waste of labor and energy apparent in large works and in big factories, as a result of noise. To the engineer, it is as cumbersome in the final analysis, as so-called hustle is to the American business man. In a recent conversation reported in Metallurgical and Chemical Engineering the superintendent of a large stamp-mill made the observation that "noise costs money." The reporter goes on to say:

"We have been discussing the use of stamps as crushing machines and the comparative merits of various devices for crushing ore. One of the arguments advanced by this superintendent against the use of stamps was the tremendous and never-ending noise produced by the falling weights. In his opinion the din was responsible for many misunderstood directions and orders to employees, resulting in confusion, loss of time, and expensive mistakes. The point is readily perceived. The average mill employee is anxious to give the impression that he understands the boss's orders, and rather than ask a question for further information he will sometimes pretend to understand and then go and seek advice from a fellow workman. The order may be wrongly executed or not at all. The noise of the stamps contributes greatly to this condition, makes it difficult to give and receive orders, and undoubtedly causes many mistakes. The cost of noise may not be estimated exactly, but it is a real factor."

These are excellent contentions. It would be interesting to hear from the efficiency engineers operating in Canada, what they are doing in the course of their effective work, to reduce noise and consequently its heavy cost.

PANAMA CANAL OPENED.

The opening to traffic of the Panama Canal on August 15th was a great event in the commercial and engineering spheres. The construction of the Canal, various phases of which have been described from time to time in *The Canadian Engineer*, is considered, and justly, one of the greatest engineering events of modern days. There has been expended to date on the purchase and construction of the Panama Canal a sum of $360,173,375.33 These expenditures have been classified as follows to May 1, 1914:—

Administration	$ 7,004,684
Law	60,109
Sanitation	17,208,154
Construction	206,117,831
General items	90,167,566
Fortifications	6,200,505

For the benefit of commerce, it comes into being when shipping is disorganized by war. It follows the opening of the Kiel Canal, which was built largely for war purposes. A peaceful vessel, the Panama Railway steamer Ancon, was the first to pass through the famous Canal from the Atlantic to the Pacific. The battleships of belligerent nations may be among the earliest visitors to the great waterway. Their passage through the Canal is governed by regulations which were formulated in times of peace. They may not remain in the Canal for more than twenty-four hours, unless specially permitted. A war vessel of one nation must not follow the exit, from the Canal, of one of another nation, until after the expiration of twenty-four hours. The Canal has been opened at an inauspicious time. Rival battle-fleets are intent on serious gunnery. Commercial fleets are idle, lame or stealthy. But better times are in store. They may have come when President Wilson, in March, 1915, presides at the international celebration which will mark the official opening of the Canal.

A boat can make in eleven hours a trip through the Canal which otherwise would have taken thirty days. That is something the world's shipping will appreciate in due course. Europe is engaged at present in work of destruction. America, in the meantime, has completed one of the greatest engineering works of construction.

PERSONAL.

MESSRS. T. T. WILSON, J. B. PHILLIPS, W. YOUNGMAN, R. WHITSIDE, and F. MINNVILLE, are engineers recently appointed to positions on the staff of the Manitoba Highway Commission.

G. GORDON GALE, since 1907 connected as a superintendent with the Hull Electric Company, has recently been promoted to the general managership of the company. Mr. Gale graduated from McGill University; and, previous to his connection with the Hull Electric Company, he was assistant engineer of the electric plant of the Canadian Rubber Company. His positions as superintendent with the former company during the past seven years have been superintendent of power, acting superintendent, and for five years, general superintendent.

J. A. RUDDICK, chief engineer of the Dominion Coal Company, Sydney, N.S., has resigned his position to accept a similar one in Canada. While in charge of the construction department of the Dominion Coal Company during the past two years, Mr. Ruddick supervised the building of the new pier for the I.C.R., the coal-washer at Whitney pier—the only one of its type in Canada—as well as several large structures in connection with the company's different collieries. No details have been announced relative to Mr. Ruddick's new appointment.

M. A. LYONS, a graduate of 1910 from the Massachusetts Institute of Technology, has been appointed to the office of Chief Engineer to the Highway Commission of Manitoba. Mr. Lyons is to have general supervision of survey, design and construction of roads and bridges under the recent "Good Roads Act" in that province. His headquarters will be in the Parliament Building, Winnipeg. In 1911, Mr. Lyons became assistant engineer for the Canadian Pacific Railway in the irrigation department; in 1912, drainage district engineer for the Manitoba department of public works; and since 1913, bridge engineer for the latter department.

OBITUARY.

The death occurred on August 25th of Roderick J. MacDonald Parke, consulting electrical engineer, member of the Canadian Society of Civil Engineers as well as of the Canadian Society of Electrical Engineers, member of the Board of Trade, and at the time of his death managing director of the Automatic Electric Cook Co., Limited, Toronto. Mr. Parke is noted as the designer of the first long distance transmission plant in Canada, viz., from the Ragged Rapids, on the Severn River, to Orillia. He was chosen by Mr. Urquhart, former mayor of Toronto, to report upon the cost of distributing electricity throughout the city; and this report was used in part when the design now in operation was being prepared. He prepared plans for the Dominion Government and supervised the lighting construction of the old Welland Canal. He was formerly head of the firm of Parke & Leith, an agency for the British Aluminum Company, Limited; and, as a result of his labors in this industry, he founded the Canada Wire and Cable Company, Limited. The firm with which Mr. Parke was connected at the time of his death was promoted to exploit a patent invented by the deceased.

ADVANCE PROGRAM FOR NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.

Part of the program to be undertaken at the annual meeting at Buffalo, N.Y., September 9th, 10th and 11th, of the National Paving Brick Manufacturers' Association, has been given out by W. P. Blair, secretary of the association. Sept. 9th will be utilized by the members for their business meeting. A discussion with the brick committee of the American Society of Municipal Improvements over specification questions will be held on the evening of the 9th. The itinerary and program on the 10th will include a trip through the city and out into the country over the older as well as the newer highways, observing those under construction. On September 11th a trip will be taken over the Niagara Boulevard to Fort Niagara. Details may be obtained from W. P. Blair, secretary, Brotherhood of Locomotive Engineers Building, Cleveland, O.

FORT WILLIAM CONVENTIONS CANCELLED.

Notice has been received from Fort William, Ont., to the effect that, due to the unsettled conditions caused by the European war, it has been necessary to cancel the annual meeting of the Canadian Public Health Association, which was to have been held in that city during the month of September.

Due to the same cause, the 1914 convention of the Associated Boards of Trade of Western Canada, which was arranged to convene at Fort William on September 8th, 9th and 10th, has been postponed for an indefinite period.

CONVENTION POSTPONED.

The convention of the Union of New Brunswick Municipalities, to be held at St. John, N.B., has been postponed until November 17th and 18th.

COMING MEETINGS.

INTERNATIONAL WATER-POWER CONGRESS.—Under the auspices of the Ministers of Public Roads and Agriculture. Second international congress, Lyons, France. September 7th to 10th.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Secretary, Will P. Blair, 832 B. of L.E. Building, Cleveland, Ohio. Eleventh annual convention and paving conference, Buffalo, N.Y., September 9th, 10th, 11th, 1914.

NEW ENGLAND WATERWORKS ASSOCIATION.—Secretary, Willard Kent, Narragansett Pier, R.I. Annual convention to be held at Boston, Mass., September 15th to 18th.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown, Indianapolis, Ind., Secretary.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Charles Carroll Brown, Secretary, Indianapolis, Ind. Meets at Somerset Hotel, Boston, Mass., October 21st, 22nd and 23rd.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.—11th Annual Convention; 5th American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau St., New York, N.Y.

Volume 27. Toronto, September 10, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

A COMBINED GAS AND STEAM ENGINE UNIT

NOTABLE UNDERTAKING INVOLVING TWO 42 x 72 IN. GAS CYLINDERS, ONE 36 x 72 IN. H.P. AND ONE 68 x 72 IN. L.P. STEAM CYLINDER TO DRIVE A COMMON SHAFT.

By M. E. GRIFFIN, Mem. A.S.M.E.,

Mechanical Engineer, Franklin, Pa.

WHEN the additions to the power plant of the Ford Motor Company, of Detroit, are completed there will be housed in one engine-room gas and steam engines capable of developing over 30,000 h.p., and the complete installation will embody many novel and interesting features.

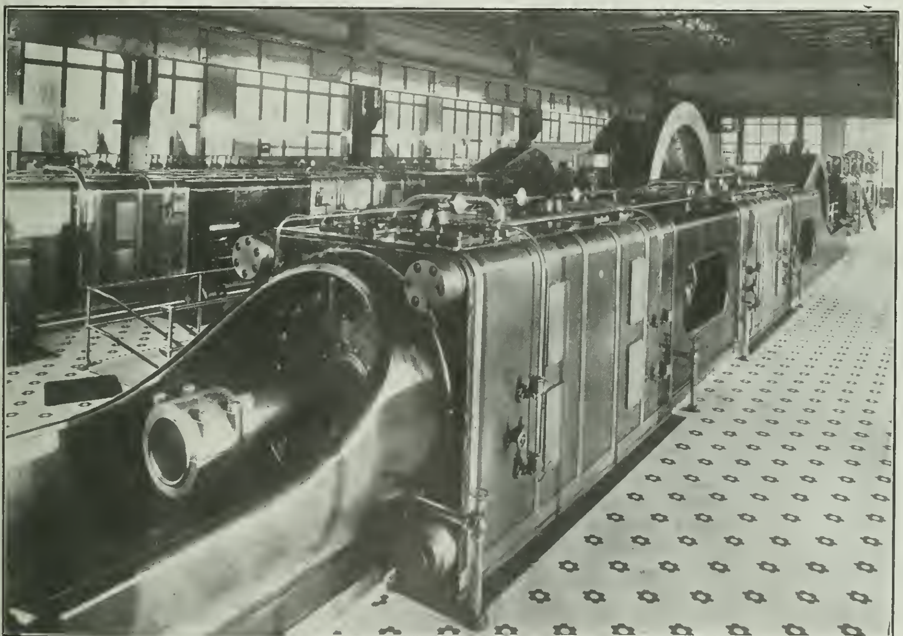


Fig. 1.—Side View, from Tail Rod End, of One of the Ford Motor Company's Engines.

When the plant was started the producer-gas engine was in great demand in the power field, and Henry Ford adopted this type of prime mover to operate his plant. His first gas engine was a 1,600 h.p., two-cylinder, double-acting tandem, having cylinders 35 in. diameter by 48 in. stroke, and operating at 100 r.p.m. This engine was direct-connected to an 850-Kw. Western Electric d.c. generator, and cross-connected to a 2,000-cu. ft. air-compressor of the central port hurricane valve design. The company from which this engine was purchased was unable to fulfil its contract and the purchasers completed its construction. This unit proved satisfactory, but the phenomenal increase in business soon necessitated additional power. Another producer-gas engine of greater capacity than any other internal combustion engine yet built in any country was decided upon. Edward Gray, the Ford mechanical engineer, designed this engine, embodying in it many special features which his many years' experience in gas engine design and operation suggested. It is what is called the one-story-and-basement type, with all the valve gear in the basement. There are 4 double-acting cylinders, 42 in. diam. by 72

in. stroke, arranged two in tandem upon each side. The engine is direct-connected to a 2,500-k.m. d.c. Crocker-Wheeler generator, and operates at 85 r.p.m., or a piston speed of 1,020 ft. per min. The generator is designed for 25% overload capacity, and the engine is rated at approximately 6,000 I.H.P.

The magnitude of this engine may be realized from the following data: The 20-ft. flywheel weighs eighty

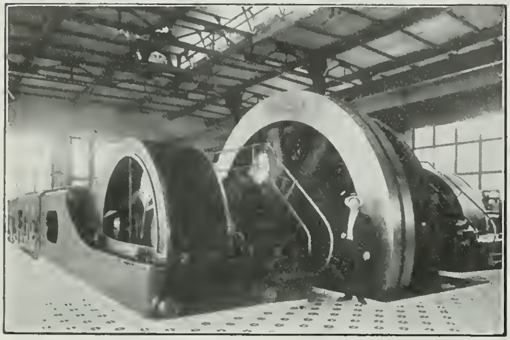


Fig. 2.—Front View of Engine in Fig. 1, Showing General Design and Massiveness.

tons, and the engine complete, without generator, weighs approximately 700 tons. The total length of the engine from rim of flywheel to the end of tail-rod guide measures 80 ft., and the overall width is 32 ft. The shaft in middle measures 32 in. in diam., and has an overall length of 26 ft., weighing, with crank discs, almost 100,000 lbs. Each complete connecting-rod weighs 10,300 lbs., and each bed or frame approximately 150,000 lbs.

Fig. 3.—Crank Shaft with Armature Rotor, Ready for Transportation.

The engine is designed symmetrically around the centre line, and the massive bed-plate, common to nearly all large gas engines, is omitted, the object being to make the engine self-contained and securely anchored on its foundation, allowing the cylinders perfect freedom to adjust themselves according to stress or temperature changes. The massive frames are reinforced longitudinally by 6-in. steel tie-rods, shrunk into place. The cylinders and distance-housings are secured to their respective beds by a continuation of 6-in. steel tie-rods and nuts.

The total weight of the pistons and rods is supported by the main, intermediate and tail-rod crossheads, all riding on bored guides. The main crosshead body is made in two parts and of annealed steel casting. The two halves or sides are held together by turned steel bolts in reamed holes, and the bolts at the throat are arranged to produce a clamping effect on the piston-rod, where it is screwed into the neck. The shoes are independent of, and secured to the crosshead by the trunnion method.

The main bearing is of massive and unusual construction, the caps being set into the housing in such a manner as to form a strut and tie, and are secured in place by 6-in. steel tie-rods placed longitudinally. The lower shells are water-cooled by means of brass coils, which were bedded in recesses in the cast-iron shell, and the babbitt metal, poured on top, encasing each, thus avoiding the possibility of trouble from waterjacket due to defective casting. The crank discs are of the counter-balanced type, made of annealed steel casting, and the crank pins are cast integral with the discs.

The lay shafts are located above the floor line, and are driven by semi-steel spiral gears from the main shaft (bronze gears were used at first, but found impracticable). These lay shafts are in sections, secured to each other by pin couplings, so that each section remains with its particular cylinder, and perfect alignment between crank and the walking-beam, which it drives, is preserved. On each lay shaft there is secured a crank for each end of the two cylinders in the set, and each crank operates both inlet and exhaust valves through the medium of the walking-beam at the end of its respective cylinder. The walking-beam and lay shaft carrier brackets are made double in order that the pins may have double support instead of being overhung. The design throughout eliminates overhung pins or bearings.

The inlet, or admission valve at each end of the cylinder, is actuated by a cam, the operating bell-crank lever of which is located between the sides of the walking-beam and pivoted at the centre. One end of the bell-crank actuates a hook, steel-faced, which engages with another hook-plate lever, fulcrumed in the projections on top sides of the walking-beam. An eccentric upon the governor shaft operates a cam, which trips the valve mechanism at any point of the stroke determined by the governor, similar to the cut-off arrangement of a Corliss steam-engine. The valve is closed by a spring, and cushioning is effected by an air dashpot. The admission is of the quantitative method, and the governor performs no other work than adjusting the position of the tripping cams.

The exhaust valve is operated by a cam, which receives its motion through a link secured to the extreme inner end of the walking-beam. The leverages of the cam are so proportioned that a very slight movement of the walking-beam produces a considerable movement of the working surface of the cam in sliding contact with the lower end of the exhaust valve projection. The arrangement is such that at a certain position the movement of the valve is rapid, but when the outer end of walking-beam is at its lower range of travel there is a pause in the exhaust valve mechanism. The pistons and rods are hollow and water-cooled. The water enters the rods at the intermediate crosshead by means of a telescopic oscillating arrangement, the outer end of which is pivoted below the engine. The piston-rod contains an inner tube for the inlet water to the pistons, and the

water outlet is around this tube, thus raising the temperature of the incoming water.

The engine just described has been in successful operation for about two years, and from the beginning of its operation the exhaust gases, instead of being wasted during the winter season, were utilized to heat water for the heating system of the immense plant. The idea of utilizing exhaust gases for this purpose is, perhaps, not a new one, but it gave rise here to an entirely original idea. When the unprecedented increase in Mr. Ford's business demanded more power he analyzed the economy question from all angles, finally deciding, if possible, to adhere to the internal combustion prime mover. From an efficiency standpoint he reasoned that he could not use nearly all the heat energy from the exhaust gases, as his system would not increase in the same ratio as the necessary power; therefore, if gas engines were to be installed, much waste heat would be the result. His final decision was for an increased installation, comprising steam and gas units, and it is without doubt one of the most daring engineering undertakings in the engine line thus far presented.

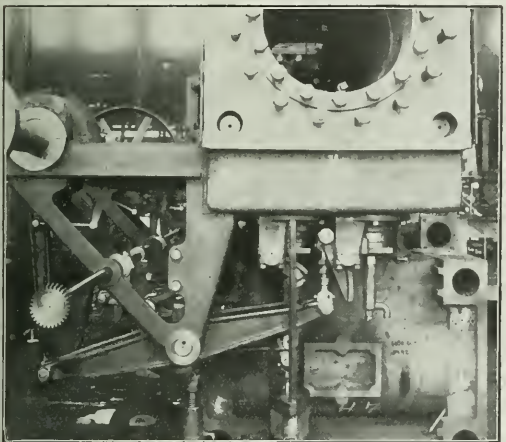


Fig. 4.—Valve Gear, with Exhaust Valve Cam in "Pause" Position.

During the past year he has placed orders for four 6,000 h.p. units, each direct-connected to a 2,250-k.w. d.c. Crocker-Wheeler generator. Each unit consists of a pair of 42 in. by 72 in. (stroke) gas cylinders, placed in tandem on one side, together with a 36-in. high-pressure and a 68-in. low-pressure by 72-in (stroke) tandem compound, condensing steam cylinder on the other side, the gas and steam engines driving a common crank shaft. The cooling water from the gas cylinders and pistons, which has its temperature raised usually to approximately 192° F., is to be used as feed water for the boilers, in which the steam will be raised to 150 pds. pressure, and, by means of a superheater employing exhaust gases, the steam will be superheated to a stage insuring its dryness. By using the available heat units thus, and operating the steam engines as condensing units, it is aimed to obtain the most economic, practical prime mover so far attempted. The intention is to use one condensing apparatus of sufficient capacity to accommodate the combined steam units, the piping and valves being arranged so as to cut one or more units in or out of commission as occasion demands.

The completion and actual operation of this new installation is awaited with keen interest by the engineering profession, because as a venture of such magnitude it possesses many intensely interesting and novel features hitherto undeveloped.

From a thermodynamic standpoint expert opinion differs, some admitting that it will be an economical success, while others argue that if the units were entirely of the internal combustion type, the total efficiency would be higher, on the supposition that the cost of coal necessary for the steam boilers, added to the initial cost of boilers, condenser, settings and auxiliaries will amount to much more than the expenditure necessary for producing gas.

Another feature causing much discussion is the question of regulation. While it is true that each new wheel will weigh 100 tons as against 80 tons in the case of the former wheel on the all-gas unit, it is also true that the impulses in the steam unit will not harmonize, so to speak, with those of the gas unit, and, therefore, the question of regulation arises, even with individual or combined governing mechanism.

The general design of the new units is similar to the former gas engine where conditions permit. The frames and all gas engine parts are duplicates of the gas engine heretofore described. The steam valve gear mechanism will be operated by lay shafts, and poppet valves are used where necessary in order to have the design of steam cylinders harmonize as nearly as possible with the gas engine cylinders. If perchance it is desired in the future to convert the units into all-gas units very little alteration will be necessary except exchanging the steam cylinders and their valve gear and piping.

UNITED STATES WATER-POWER BILL.

The water-power bill, relating to the construction of dams across navigable streams, and known as the Adamson bill, was passed by the House of Representatives of the United States on August 4. In accordance with its requirements, plans and specifications for such dams must be approved by the Secretary of War and the Chief of Engineers before work of construction is commenced. Approval may include the condition that water-power to operate locks, etc., be supplied without cost, or a reasonable annual charge may be made for the benefits that accrue to the grantee by the authority given under the act. The dam shall be located so as to be best adapted to a comprehensive plan for the improvement of the waterway for the use of navigation and for the full development of the water-power. The rights granted under the act extend over a period of 50 years beginning on the date of the original approval. Upon two years' notice prior to the expiration of the grant, the United States has the right to take over the property of the grantee necessary and useful for the generation, transmission and distribution of energy, the payment therefor being based on the actual cost of the lands purchased and used by the grantee and the fair value of the other properties taken over. Allowance will be made for deterioration but not for goodwill or profit in pending contracts. The Secretary of War is empowered to prescribe reasonable rates of charges for energy transmitted in "interstate or foreign commerce." When the energy is used within a state having adequate regulation for rates and service to the consumer the Secretary of War will not interfere with the established rules for rates and service.

The semi-annual report of the operation of towns and cities, included in the hydro-electric system, for the first six months of 1914 shows surpluses in every case. A number of reductions will result. The city of Galt, with an average monthly surplus of over $1,000, gets a 16 per cent. reduction which brings the domestic rate to about 2½ cents. Other towns are eager for reductions and it is expected a number will be granted. Toronto's rates have not yet been finally determined.

THE CORROSION OF IRON.

By F. N. Speller, B.A.Sc.,
Metallurgical Engineer, Pittsburgh, Pa.

In writing on the "Corrosion-Resisting Qualities of Modern Mild Steel vs. Old-Time Iron" in *The Canadian Engineer* of June 4th, 1914, Mr. A. T. Enlow draws attention to a few of the erroneous ideas which prevail on this subject which have been quite generally overlooked in recent discussions. Some of these points are of such practical importance that they will bear referring to again. He emphasizes the fact that chemical analyses showing the sulphur, phosphorus, silicon and manganese (and he might have added oxides and slag) may be very misleading as to the enduring qualities of the metal. He goes on to say: "The idea that the analysis tells the whole story has its origin in the statement, so often reiterated when the idea of a modern rust-resisting metal was first conceived several years ago, that 'the purer the material as regards the absence of foreign chemical elements, the better would it withstand corrosion.' At best this statement only conveys part of the truth."

Referring to the exceptional cases where old-time iron has withstood the ravages of time to such an extent as to be, in some cases, in a state of good preservation to-day, Mr. Enlow points out that this is no proof that the old-time irons were all of this character—quite the reverse is the case—for the few samples which can now be found are merely the survival of the fittest. In speculating as to the cause of the long life shown in these exceptional cases by old-time iron the author seems to reach the conclusions that this was due to the absence of manganese in this iron and the presence of something which, perhaps for lack of a more definite term, he calls "vitality." This, it is presumed, is lacking in iron which shows more rapid corrosion. There is no question but that modern iron and steel, no matter by what process it has been made, varies to some degree in quality according to how carefully the metal has been refined and worked. This was most probably true, if not to a greater extent, in regard to the old-time iron referred to.

Regarding the effect of manganese, I believe the author is inconsistent and reaches a conclusion which is not supported by evidence. It is well known that manganese alloys with iron more uniformly than any other element and shows very little tendency to segregate. Many comparisons have been made of low-carbon steel made in the open-hearth furnace without manganese and ordinary soft steel carrying .30 to .40 per cent. manganese. On the whole, these tests show no decided difference in corrosion. The writer has had an opportunity of studying the effect of hot aerated water in pipe lines made up of modern puddled iron and soft steel. Here the conditions as to uniformity were ideal. From over one hundred of such comparisons no difference in the extent or depth of the corrosion could be seen, although the wrought iron had a mere trace of manganese, and the soft steel carried over .30 per cent.; so that the manganese is no exception to the general conclusion which Mr. Enlow has drawn that "chemical analysis of the carbon, sulphur, phosphorus, silicon and manganese may mean much or little."

As to the absence or presence of "vitality," it is true that by aiming at exceptional purity and not using such additions as ferro-manganese, properly applied, the steel may be rendered very sensitive to subsequent heating, and, as a practical welder would say, "it is dry." The metal in this state may have a very high degree of purity as in the case of so-called "ingot iron," but probably due to this extreme purity it readily absorbs gases when heated, and when fabricated may be decidedly inferior to soft steel carefully made by standard practice and carrying sufficient manganese to protect the iron from oxidation.

While in the writer's opinion the various operations of refining and working the metal have a bearing on corrosion, there is another factor of far more importance which is too often overlooked. The writer had an opportunity a few years ago to study some old iron of French manufacture on the Panama Canal which had shown remarkable resistance to corrosion under adverse conditions. This material was found to be of a variable analysis, corresponding to modern soft steel in some cases and in others the metal was evidently made by the puddling process. A close examination showed that corrosion had not penetrated through the surface of the metal, which was protected by a film of tenacious scale. Upon removing this surface skin and exposing the clean metal under the same conditions it was found to corrode as rapidly as modern soft steel. This was tried out a number of times where other instances of more or less perfectly preserved old iron have come to light, and it invariably proved that on removing the protective skin from these metals corrosion proceeds quite rapidly, the metal being destroyed apparently as fast as in the case of unprotected steel of modern manufacture.

Considering the fact that the iron and steel made up to 30 or 40 years ago was slowly fabricated, so that, especially where hand-forged, the finish was not nearly so smooth as nowadays, it seems that the film of cinder which was left on the surface of the forged article adhered tenaciously, and in most cases was responsible for preserving the metal from corrosion. In some cases these cinders are in the nature of a thin enamel and are quite impervious to moisture.

From our experience I am quite in accord with the author's conclusion that "the physical qualities unquestionably have very much to do with this question . . .," but I am inclined to question the statement that as a rule old irons are more dense than modern mild steel. It is very important, in my opinion, that the metal be uniformly finished in the final stages of refining and afterwards carefully heated and given as much work as possible in the process of fabrication. It is of advantage to apply this work in more than one direction, as in forging operations, so as to get as uniform density as possible, and in working metal in this way as far as practicable all loose scale should be removed from the metal between passes so that the finished surface may be as uniform as possible. This is the ideal to which we have been working in the manufacture of soft steel to withstand corrosion. It is obviously impracticable to make the large tonnage which is produced nowadays by the old-time methods, even though it was proved that iron so made had superior durability. Modern requirements call for a smoother finish, and protection, where required, should be applied to the carefully-prepared surface after fabrication.

After all, it seems that durability in service is more often a question of protection of the surface of the metal from moisture, either accidental or by means of protective coatings, than by virtue of any inherent quality in the metal itself. Chemical composition, *per se*, so far as the common metalloids are concerned, seems to have less influence on the corrosion of iron than any other factor.

COST OF CANADIAN RAILWAY CONSTRUCTION

MOST RECENT COMPILATION OF FIGURES FROM CONSTRUCTION ACCOUNTS OF CANADIAN RAILWAYS, GIVING DETAILED AND ORIGINAL STATISTICS FOR THE YEARS 1906-1913.

By J. L. PAYNE,
Comptroller of Statistics, Department of Railways and Canals, Dominion Government, Ottawa.

THE construction account of Canadian railways during the past decade runs into amazing figures. I cannot, however, go into details for the years prior to 1907, in which year an entirely new system of statistics was made effective, and must, therefore, content myself in this relation to deal with the facts since 1906. For that seven-year period, from 1907 to 1913, inclusive, there was an addition to capitalization of $465,949,063, or an average of $66,564,152 per annum. Cash aid by the Dominion, the provinces and municipalities amounted to $49,171,811 during the same term, or at the rate of $7,024,544 per year. Joining these two items of capitalization and aid, we have a total for seven years of $515,120,874, which would be equal to an average of $73,588,695 per annum. It might fairly be assumed that this large total represented the outlay, dollar for dollar, on construction. The increased capitalization includes $193,000,000 of stocks, which ordinarily would yield little or nothing in cash; but, in this instance, all but $65,000,000 of the aggregate has been made up of Canadian Pacific issues, which were sold at a substantial premium. It might, therefore, be taken for granted that the actual expenditure did not fall far short of the liability.

On the assumption that construction cost is fairly represented in the growth of capital liability, plus cash aid, two or three interesting facts are disclosed by analysis. During the seven years immediately under review, 7,951 miles were added to operative mileage in the Dominion. Of course, all the capitalization in question did not produce railway mileage in actual operation in 1913. Liability must necessarily precede the handling of traffic. On the other hand, there was undoubtedly more than $100,000,000 worth of bonds outstanding which had not been brought into the account; so that operative mileage left out might be regarded as balancing liability omitted. On that basis of calculation, since 1906 capitalization equalled $58,410 per mile per annum, and cash aid $6,183 per mile per annum. Such averages clearly show that (1), on the whole, we have been building railways up to a good standard, and (2) that public aid has been extended in generous measure. It is not straining the truth to say that no other country has been making such great sacrifices to provide itself with transportation facilities.

The cash aid of something like $5 per family per annum during the past seven years is only part of the story. Within a little over ten years the Canadian people has made itself liable for principal and interest in connection with guarantees of bonds aggregating $320,000,000, including the liability of $45,000,000 on account of the Canadian Northern, voted by Parliament in May last. This would bring the total of aid in cash and guarantees up to not less than $25 per family per annum during the past decade. It may demonstrate a splendid faith, or, in another aspect, it may merely reflect a sense of urgent need. No matter in what light it may be regarded, the liability, direct and indirect, is a matter of serious importance. The Canadian Northern has received a large proportion of the aid, both in cash and guarantees; and that system will unavoidably have a considerable unproductive mileage for some years to come. That is to say, the construction work it has had under way, and is about to undertake, lies very largely in those portions of the north-west which have not hitherto been served by railways; and it is a railway axiom that pioneer mileage does well if it earns operating expenses for the first three years. Nevertheless, the rapid settlement of the western provinces may create traffic quite sufficient to provide for the large fixed charges of the Canadian Northern system when it has been completed and placed on an operating basis.

The construction of the Moncton-Winnipeg section of the Grand Trunk Pacific should also be taken into the account of public aid to railways. The expenditure by Government on this work has already reached $150,000,000, and the Minister of Finance has stated in Parliament that the final cost will be $235,000,000, including interest on capital outlay up to such time as the agreement with the company which is to take it over becomes effective. This would bring the public contribution up to a little over $34 per family per annum during the past ten years, with more to come. The cost of the Transcontinental has been placed at $100,000 per mile, and this fact should carry with it the assurance that Government has built 1,805 miles of line up to a standard not hitherto attempted in Canada. Whether or not Government was setting a pattern, it is obvious that the days of cheap and more or less makeshift railway construction have passed. A low-grade railway may have been defensible in earlier times. It was a case of that kind of construction or nothing. But in these days it is recognized as sheer waste to follow such methods. Experience has amply demonstrated that it is true economy to build on sound lines and with a view to future needs.

If, however, Canada has added on a large scale to her capital liability on railway account during the past seven years, it is clear that the next seven years, barring some extraordinary disturbance in the financial situation, will establish new records in both expenditure and additional mileage. This prediction is not based on mere optimism. It rests on facts. Just a year ago there were in the Dominion 18,648 miles of line in various stages of construction. That was more than the entire operative mileage of the country in 1901. Of these 18,648 miles reported as being "under construction," nearly 9,000 miles were actually under contract. About 3,500 miles were completed, and 6,560 miles had not passed the survey stage. These are big figures. While this vast work was scattered all the way between the two oceans, more than 70 per cent. of it was located west of Ontario. At this moment it cannot be said how many miles were moved into the operating column during the past year; but for every mile completed, it is probable the construc-

tion of another mile was begun. It will involve a very large expenditure to carry this mileage to a finish and to equip it for the movement of traffic. It will also mean the employment of an army of men not now identified with transportation.

The labor aspect of railway operations in Canada is not generally recognized. It may not be amiss, therefore, to present a few facts in that regard. In 1913 there were 609 employees per 100 miles of line, as compared with 551 in 1907. This magnitude will increase with the growth of traffic. The total number last year was 178,652; and that figure represents an average increase of nearly 10,000 per annum during the past six years. The wages bill in 1913 reached the large total of $115,749,825, and made up 63.59 per cent. of operating expenses. In fact, if the matter be carefully examined, it will be found that, directly and indirectly, transportation interests provide a living for about 20 per cent. of the entire population of the Dominion. On the other hand, the cost of transportation, viewed as a tax, rises above all other public imposts, both in magnitude and distribution. Speaking broadly, nobody can escape the levy for carriage, or its incidence; whereas customs, municipal and other forms of taxation may in large measure be avoided by a considerable number in every community.

The ancient controversy as to the priority of the hen or the egg has its counterpart in the question as to whether transportation facilities create trade or trade creates transportation facilities. Without expressing any opinion on the subject, I have long been watching the co-ordination of these forces; for they do co-ordinate. Traffic and trade must move together. They are dependent on each other. Trade cannot grow without marketing facilities; and, just as the ship preceded settlement, so the railway must provide the channel for a nation's commerce, otherwise, there will not be any considerable volume of commerce. Leaving the matter at that point, it will be helpful to see by ten-year periods how Canada's railway mileage has grown. Here are the facts:—

	Miles.		Miles.
1863	2,189	1893	15,005
1873	3,832	1903	18,988
1883	9,577	1913	29,304

Traffic has moved upward with available mileage. Could old and new mileage be separated, it would undoubtedly be found that the former carries the larger proportion of traffic. New mileage, as has been said, must to a large extent develop its business; and this is often a slow process. The following little table shows the total tonnage hauled and the volume per mile of line since 1883:—

	Tonnage.	Per mile of line.
1883	13,266,255	1,384
1893	22,003,599	1,466
1903	47,373,417	2,495
1913	106,992,710	3,651

It will be observed that the productivity of old mileage has more than offset the dilution brought about by new mileage; and the table as a whole may be taken as showing in a most striking way the expansion of the Dominion during the past thirty years. That expansion is exemplified in the fact that while there was the largest addition to mileage between 1903 and 1913 there occurred during that same decade the largest increase of freight traffic. Passenger business does not show the same ratio of development, as the following table makes plain:—

	Passengers.	Per mile of line.
1883	9,579,984	1,000
1893	13,618,027	907
1903	22,148,742	1,166
1913	46,230,765	1,577

There has been little change during recent years in the proportionate relationship of commodities to the total volume of traffic. For example, products of agriculture made up 16.85 per cent. in 1907, and stood at 16.31 per cent. in 1913. Products of mines and manufactures have shown the principal growth. The former grew from 18,460,172 tons in 1907 to 40,230,542 tons in 1913, while the latter expanded from 7,974,641 tons to 19,694,240 tons during the same period. Nevertheless, the percentage of each class to the whole was not materially altered, except in those two cases. This would seem to show that production has followed along constant lines, and that growth, as represented in traffic, has been fairly uniform among the seven classes.

In no other respect does the widening of Canadian railway interests show up so impressively as in earning power. Going no farther back than 1888, and giving the facts at five-year intervals, the following table tells a strong story:—

1888	$42,159,152	1903	$ 96,064,526
1893	52,042,396	1908	146,918,314
1898	59,715,105	1913	256,702,703

It will be seen that as between 1888 and 1898 there was an increase of 41.6 per cent., whereas between 1903 and 1913 the betterment amounted to 167.2. This highly satisfactory result was achieved without any increase whatever in ratio. Net earnings showed up equally well. As between gross receipts and operating expenses—the popular method of measuring net earnings, but not the sound way—there was an advance from $11,507,106 in 1888 to $74,691,013 in 1913. Thus, while gross earnings grew by 509 per cent. during the whole period of 25 years, net earnings grew by 548 per cent. During at least 18 years of that period, there was on one hand a slight reduction of freight rates; while on the other there was a steady and pronounced advance in operating cost as represented chiefly in wages, prices for materials, and so on. Our railways have, therefore, raised net earnings very largely by better methods of operation.

At this point it would seem to be opportune to pause and ask: What, probably, will be the effect of the war now under way on the railways of Canada? No one knows; no one can do more than conjecture. The situation is as novel as it is staggering. It is a distressing topic, since war in all its aspects means waste. War is destructive and not constructive. To just the extent that Canadian commerce is hindered and production restricted there will inevitably be a reduction in the volume of traffic. Traffic is the life blood of railways. As it declines earnings fall off, and as earnings fall off the railways must cut down operating cost. The immediate effect of such economies will be a diminution of the pay roll, and we have already seen that salaries and wages make up 60 per cent. of operating expenses. The injury does not, however, end there. For every five persons who obtain a livelihood directly from the operation of railways at least one other person is dependent on that source indirectly. It therefore calls for no particular prescience to foretell a hard and trying year before the railways of Canada and all associated interests.

How far will the war bring about an enforced halt in construction work? The importance and far-reaching

nature of such a question is obvious. Many thousands of miles of new line are in process of building, and other vast projects are assuming positive shape. The money markets of the world have been paralyzed, and money to the railway builder is what traffic is to the railroad operator. Therefore, we must look for some let-up in construction activity. It is inevitable. Let us hope it may be of short duration. When the war is over, we are likely to see a period of unparalleled expansion in Canada. We have the inchoate material for a development beyond our most sanguine dreams.

From the railway point of view, the recent troubled situation has been hurled upon us when we were proud of our progress and strong in our faith. Our railways had established a surprising record of growth, and great plans, expressive both of our transportation needs and our accumulating energy, were under way. In 1913 they had made an unprecedented addition to equipment, and were in a fine position to meet a swelling of traffic. Had all this happened as the result of mismanagement or miscalculation, from some cause suggesting internal weakness, the situation would be vastly different; but it came when our railway situation, viewed as a whole, was sturdy and sound. Therefore, while we may be embarrassed, we shall be able to take up again the immense work on this northern half of the American continent pretty much at the point where it suffered interruption.

NEW PLANT FOR TREATMENT OF WOODEN POLES.

The Lindsley Bros. Company are just installing at their pole yard in Nakusp, B.C., a plant for treating the butts of their British Columbia cedar poles. For the past two years this company has been operating a similar plant at Priest River, Idaho, and last year treated over 5,000 poles.

The treatment in this plant, as also in the Nakusp plant, just installed, consists in immersing the butts to a point 12 inches to 18 inches above the ground line in genuine avenerius carbolinium at approximately 200 deg. F. for a period varing from 10 to 20 minutes; the period of immersion varying with the condition of the poles and time of the year. It is found that this immersion is the most efficient and gives a penetration of the entire sapwood of the butt—the only place where decay is likely to affect the pole.

At the present time this company is treating some 7,000 poles for the Great Falls Power Company of Butte, Montana, which will be used in a 100,000-volt transmission line to be erected between Great Falls and Anaconda and designed to carry power for the electrification of the Chicago, Milwaukee and St. Paul Railway. About 4,000 of these poles, which are from 45 to 50 feet long, will be used for the main transmission line which will be of "A" frame construction with six unit, suspension type insulators. This will probably be the highest voltage transmitted anywhere in the world on wooden poles and is all the more significant as the Grand Falls Power Company have had considerable experience with steel towers. At the present time they have a 60,000-volt line and an 80,000-volt line carried on wooden poles.

This year the company have entered orders for over 12,000, their customers including some of the most prominent public service corporations in the United States and Canada, one of these being the municipal electric light plant of Ottawa, Ont.

SINKING A SEA-OUTLET.

In the treatment of sewage in seacoast towns, it has become the custom in almost all cases to use retaining tanks at a point close to the beach. The sewage is brought to this point and there passes through these tanks, giving a liquid effluent, and holding back the solid matter which is broken up, and the natural action of putrefaction takes place.

With the objection of having solid matter washed back on the beach, removed, it only remains necessary to place the liquid effluent at such a distance from the shore, and in a sufficient depth of water to insure a perfect dilution. Here the sewage effluent, being lighter, rises to the surface, mixes with the seawater, the dissolved oxygen of which completes the purification. This has been found very satisfactory in a depth of 20 feet or more of water, and at a distance of approximately 1,000 feet from shore.

So the problem arises to construct a sea-outlet which will withstand the heavy storms occurring along the coast during the winter months, for a sum of money within reach of the average seacoast town.

Fig. 1.—Twelve-Inch Pipe, 1,000 ft. Long, Being Submerged After Assembling on Shores.

An outfall was described by W. M. Aitchison, C.E., in a recent issue of "The Cornell Civil Engineer" that is worthy of note. It was installed April 22nd, 1913, to take care of the sewage of West Grove, New Jersey. After passing through the settling tanks in West Grove, the sewage flows through Ocean Grove to a manhole near the ocean from between the board-walk and the street, and from this manhole through the sea outlet into the ocean.

The outfall line was made up of 12-inch galvanized wrought iron pipe. The pipe came in lengths averaging 21 ft. and weighing approximately 48 lbs. per ft., with threaded joints fitting into recessed couplings.

While the material was being put on the ground a 3-drum hoisting engine was set up on the beach near the point where the pipe was to be installed. This being the anchorage of the whole operation, great care was used to have a substantial base. Eight-foot piles were driven in the sand, cross braced and capped, and the hoisting engine bolted to these caps.

For an off-shore anchorage five anchors were set at a place in a direct line with the proposed outfall, and at a distance of about 1,325 ft. from shore. The distance was determined with a light line drawn taut. The anchors were set in a line leading away from shore, the two nearest weighing 500 pounds and the remainder being somewhat lighter. These anchors were fastened together with a steel cable, and an 18-inch sheave attached to the nearest

anchor. Through this was run a ⅝-inch steel cable and both ends brought ashore.

The outlet end of this line was made up with a 45° L, looking upward, and a nipple leading into another 45° L reversed, allowing the open end when completed to be six feet from the bottom, thus being out of danger from filling with sand or becoming otherwise clogged.

A sea-anchor of the contractors' own design, and consisting of two castings and two clamps was fastened to the riser just described. One clamp was bolted over the nipple leading from the lower 45° L, and the other over the main pipe just in back of the same L, both clamps fitting close to the pipe. These were held by eight one-inch bolts. The sea-anchor weighed 2,200 lbs. in all, and was assembled on the beach just above high-water mark.

Starting at the lower L the pipes were joined together with the recessed couplings, the threads being painted with white lead to insure watertightness. Platforms were built at intervals of about 30 ft. from this point into the street. Rollers were set on these platforms at such elevations as would give an even fall from the street level and the pipe line was built up on these rollers.

Fig. 2.—View of Pipe After Being Hauled Overboard.

A street leading from the ocean at this point formed a very convenient means to continue the work on the pipe line. The pipes were assembled on this street and raised on small wooden trucks, the latter being fastened at intervals equivalent to a length and a half of pipe, until the entire length from the river was sufficient to place it 1,200 ft. from the inlet point and have the last pipe above high-water mark on the beach. This much completed, there was 1,000 ft. of pipe intact, starting at high-water mark and extending in shore, all resting on either trucks or rollers.

The sea-anchor was carried on a big truck with two wheels six feet in diameter, made of two thicknesses of 2-in. plank and each having a rim of 2-in. by 8-in. plank to afford surface bearing.

A hook on the rear of the axle fitted into an eye on the rear of the coupling, thus supporting the sea-anchor and riser, and holding the same free from the ground. Extending out from the axle was a long tongue, at the end of which was a clevice. One end of the steel cable already running through the 18-in. sheave off shore was passed through this clevice and fastened firmly to the sea-anchor, with the other end on a drum of the hoisting engine.

The open end of the riser was next stopped up by means of a wooden plug inserted with white lead. So, with the outer end watertight and raised on a truck the entire line is ready and in a movable position.

The hoisting engine was then used to haul the entire length to sea (Fig. 1), the weight of the sea-anchor keeping the truck and outer end of the bottom, and the air in the pipe causing the balance of line to be bouyed up. A 3-in. pipe line extending through the entire length of large pipe acted as ballast and held the line partly submerged. This condition removed all of the unnecessary friction, and left only the resistance of the large truck holding the sea-anchor and the small trucks and rollers supporting the pipe. This diminished as the pipe went farther to sea. The small trucks were removed as they came up to the platform supporting the rollers.

The object of the sea-anchor being suspended by this hook and eye method, it will be noted, is to form a convenient means of depositing the pipe in its place when so desired. When the cable line is slackened the weight of the sea-anchor pulls the rear of the axle down, and the tongue up, and at the same time the hook releases the eye, and the sea-anchor is dropped in its permanent place.

The hauling finished, the five anchors off shore were raised singly, starting with the most distant anchor and coming in. This slackened the cable and dropped the sea-anchor. The cable was then cut as close as possible to the arm-anchor, releasing the truck, and with this the off-shore work was completed. Fig. 2 shows the pipe after being hauled overboard.

The open end in shore, at a point just above high-water mark was reduced to a 2-in. bushing, and water was pumped through this into the large pipe until a pressure of about 40 pounds was reached, thereby blowing the wooden plug out of the riser and sinking the remainder of the pipe in its place.

A block and fall was used in shore to relieve the strain on the five off-shore anchors, one end fastened to the 12-in. pipe and the other to a second drum on the hoisting engine. It was estimated that a force of about ten tons was required to haul the pipe overboard, this diminishing as the work progressed.

Next the in-shore end was lowered to its proper depth and the line continued to the manhole.

One of the largest factors to be contended with is the shore current, tending to bend the pipe out of line before it is lowered to the bottom. This makes it imperative that the temporary anchors and the engine base be absolutely secure before the hauling is underway. Another difficulty is the necessity of awaiting the proper weather conditions. While it took but 2½ weeks to put everything in readiness it was a considerably longer time before a combined light westerly wind and low tide made possible its completion.

The total, actual pulling time required was 39½ minutes in the intervals of about 5 minutes each, with lapses between to make sure every part was in proper working order. The total time from start of haul to finish was 2 hours and 15 minutes. At the start of the haul the pipe moved at a rate of 20 ft. in one minute while approaching the end it had increased to 20 ft. in 13 seconds. The average working force was six men, with about six added on the day of the haul overboard.

NOTES ON THE DESIGN OF SEWERAGE REGULATORS AND STORM WATER OVERFLOWS.

In *The Canadian Engineer* for August 27th an article was published on the design of the new intercepting sewers for the City of Cincinnati and the investigative work leading up to their design. In connection with it there will have been noted that adequate provision was not made therein for the entire storm water run-off, and that the excess is to be taken care of by separate storm water overflows. This subject, together with that of sewage flow regulation, is also treated in the Cincinnati sewerage report, and from it the following is abstracted:—

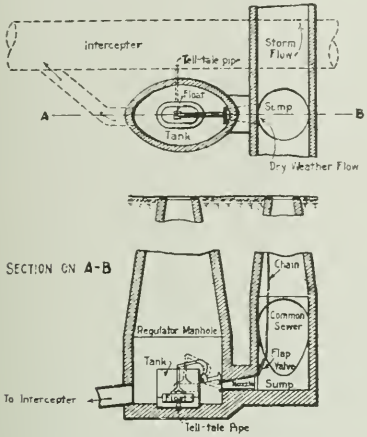


Fig. 1.—Typical Sewer Regulator.

The function of a storm water overflow is to supply a means of removing storm water in excess of a certain definite flow in the sewer to the nearest watercourse, or to a storm water channel provided for that purpose; in other words, to allow the escape from the sewer of all excess over a fixed quantity of sewage. A sewage flow regulator, conversely, is intended to prevent surcharging of an intercepting sewer by partly or wholly closing the inlet connections from the branch trunk sewers. The general object to be attained is the same in both cases, namely, to allow the admission of domestic sewage to the intercepting sewer and to divert the storm water to other channels; but an overflow provides an outlet for storm water from a trunk sewer, while a regulator prevents the admission of storm water to an intercepter.

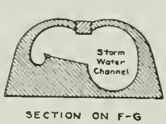
Overflows and regulators are frequently used in combination, the former allowing the excess above a certain flow to be discharged into storm water drains, the latter entirely cutting off inflow to the intercepter when the quantity of sewage in the latter has reached a certain point and when it is in danger of being surcharged.

Regulators.—A regulator is a mechanical appliance by which a gate is automatically closed by the rising of a float whose motion is controlled by the elevation of the sewage in the intercepter. A typical regulator is shown in Fig. 1.

The use of regulators of this type is open to the objection that frequent attendance is required in order to keep the apparatus in proper working condition. The regulators must be inspected and cleaned at short intervals, and after each storm must be carefully overhauled, if they are to be depended upon to perform their function.

Over-Fall Weirs.—There are two types of storm overflow, over-fall weirs and leaping weirs. An over-fall weir, as the name implies, is an outlet with a sill or crest arranged either across the sewer or longitudinally in one side of the structure, so designed that the excess flow, after the sewage reaches the height of the crest, is taken to a storm water channel, while the ordinary flow passes the weir and is discharged into the intercepter.

An excellent example of an overflow of this type is shown in Fig. 2, which illustrates the storm water overflow constructed in connection with the Walworth sewer in Cleveland, according to the designs of W. G. Parmley. In the case of large sewers, such as the one illustrated, an over-fall of considerable length is required. In this particular example the length of the crest was approximately 100 ft.



An overflow of this type, if properly designed, should be absolutely automatic in its action and should require no particular attention. The only objection to its use is that gravel and sand washes along the bottom of the sewer and the larger stones brought down by storm water do not pass over the weir, but follow the line of the intercepting sewer, which, therefore, receives practically all of the grit and is more likely to be obstructed by accumulations than if the heavy material brought down by storm water could be discharged with the overflow. This also involves undue wear upon the invert of the intercepter.

Leaping Weirs.—The leaping weir type of overflow is suitable only for comparatively small sewers. As the name implies, it consists of a weir or crest over which the ordinary or dry weather flow falls into a connection leading to the intercepting sewer, while the storm waters leap the opening and pass on through the storm water channel.

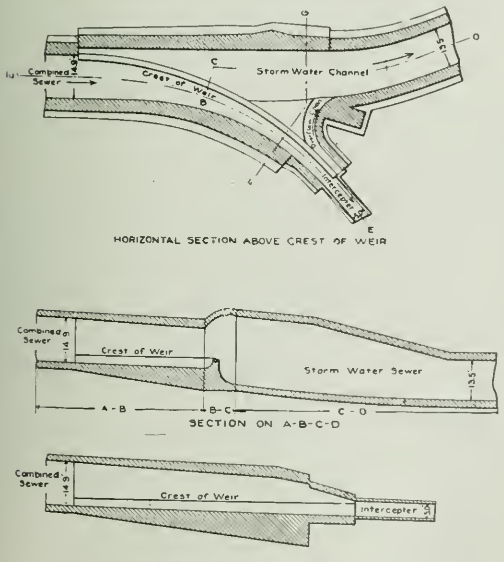


Fig. 2.—Overfall Weir for Storm Water Overflow.

A typical leaping weir is shown in Fig. 3, which illustrates an inlet constructed in connection with the Menomonie Intercepter at Milwaukee, Wis., from designs of George H. Benzenberg. Like the overflow weir, this type should require no attention, unless the opening becomes clogged by planks or other large substances which are not supposed to find their way into sewers, although they sometimes do. It is open to the same objection as the over-fall weir, that the gravel and sand are washed into the intercepter, although there is more likelihood with this type of overflow that a portion of the silt may be discharged with the storm water.

In view of the attention necessary to maintain regulators in proper working order, it is desirable to avoid their use as far as possible. Wherever found possible by studies of the details of design, the leaping weir type

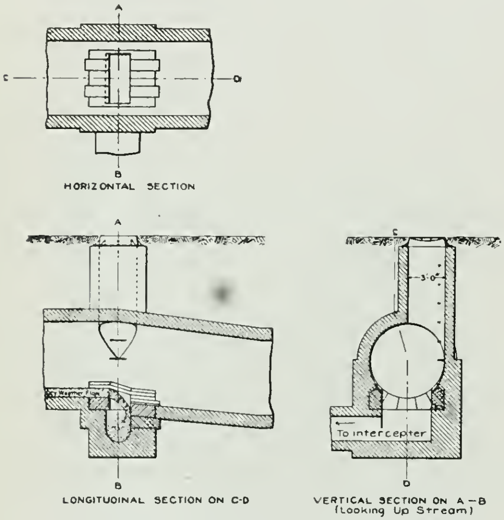


Fig. 3.—Typical "Leaping Weir" for Storm Water Overflow.

of overflow for the connections of the smaller trunk sewers and the over-fall weir for the larger sewers should be used rather than float-operated regulators.

It must not be forgotten that in the case of trunk sewer outlets which are below the level of high water in the river, so-called tide-gates must be provided, particularly in any project which involves pumping and treating the sewage collected by the intercepters; otherwise river water will at times enter the intercepter through the storm water overflows.

It is reported that timber limits extending over 115 square miles along the foreshore of Seymour Inlet and adjacent waters in British Columbia, including 3,000,000,000 feet of high-grade cedar, were recently transferred to a syndicate of capitalists from the United States. It is said to be the intention of the purchasers to begin logging operations on the limits in the near future, and the plans contemplate placing several sawmills on the property. The scarcity of cedar and the increasing price of high-grade timber in the United States have caused American millmen to turn their attention to British Columbia, which has the largest compact area of merchantable timber on the continent. The abolition of the duty on Canadian shingles and other forest products has encouraged and given impetus to the shingle industry, which has made great progress in the province recently.

OTTAWA WATER DISTRIBUTION.

A COMPREHENSIVE review of the present water system at Ottawa, tests made upon its efficiency, the requirements necessary to afford modern fire protection, a plan of the immediate and future improvements recommended, together with detailed estimates of the cost of these improvements, are presented to the City of Ottawa in a report by R. S. and W. S. Lea. A short digest has been made from this report and is given in the following paragraphs.

Ottawa's water system is operated by direct pumping at from 80 to 90 lbs. normal pressure and fire pressures up to 110 lbs. The supply is taken from the Ottawa River and almost all of it is pumped by water power. Over 40% of the system is 5-inch pipe; and, as a whole, the pipes are smaller than are usually found in cities of the size of Ottawa, even those having the oldest of systems. A comparison of the Ottawa system with those of five Massachusetts cities follows:

City.	Estimated population, (1913)	Average size of pipe. (Inches)	Relative capacity of system.
Ottawa, Ont.	100,000	6.4	1.00
Springfield, Mass.	100,400	10.5	3.66
Lynn, Mass.	97,500	8.0	1.80
Lowell, Mass.	110,100	9.2	2.59
Cambridge, Mass. ...	109,300	8.7	2.24
New Bedford, Mass. ..	112,500	9.0	2.45

In order to determine the normal capacity of the present system, a series of tests was made, using pressure gauges on the hydrants and a Curtis stream gauge at the nozzles, which were attached to 50 feet of hose. From these tests, the actual loss of head between the pumping station and any section of the city with ordinary domestic draft could be determined, as well as the additional loss resulting from a draft for fire purposes, not only at the hydrants from which water was drawn, but also both in their immediate vicinity and between this section and the pumping station. About 1,200 readings were taken in all.

It was found also that the friction losses in the system were, in many cases, three times what they would be with the usual permissible velocity of flow in the main pipes. Moreover, the hydrant pressures were below the commonly accepted standards.

The present population of Ottawa is about 100,000, and this population may be expected to at least double in the next twenty-five of thirty years. Rockliffe is the only section outside the city limits at present served by the Ottawa water system; but it is believed that provision should be made for supplying suburban districts in the future, since the city will probably be in a position to furnish water more cheaply than it can be obtained from a number of individual plants. More important still, the city cannot obtain the fullest advantages from its own proposed pure water supply if questionable supplies be continued in the suburbs.

The combined use and waste of water in Ottawa per capita is practically twice what it should be. Pitometer surveys and house-to-house inspections are in progress, with the object of finding the causes of the waste and reducing it.

The excessive normal draft per capita in Ottawa may be attributed to one or more of the following causes:

(1) The use of large quantities of water for power and manufacturing purposes;

(2) Carelessness in leaving taps running;
(3) Leakage from defective plumbing and fixtures;
(4) Leakage from the underground system.

The use of water for power and manufacturing purposes can be reduced to legitimate proportions by metering the supplies to such establishments. Education and inspection will probably reduce the losses due to (2). A long-continued extravagance in the use of water, however, becomes a habit, and no practicable method of effectively reducing it is known, except that of metering the domestic services. Leakage from defective plumbing and fixtures can be controlled by a systematic house-to-house inspection regularly maintained by a permanent corps, or by metering the services. The determination of underground leakage, the location of the leaks and their repair, is a work which may take much time, patience and money.

Obviously, the way to deal with the situation is, first, to determine for what proportion of the total waste each of the causes is responsible; after which remedial measures may be applied if their adoption is warranted by the waste it is practicable to prevent thereby.

Before permanently adopting any of the remedial measures referred to above, it is suggested that small sections of the system be chosen in typical residential, semi-commercial and business districts, and that their consumption be recorded for some time by means of a photo-pitometer or a Deacon meter. If there are any establishments in these sections using water for power or manufacturing purposes, these particular services should be metered. The number of domestic services and the number of consumers should be determined. After records from these small sections have been taken long enough to indicate the per capita domestic consumption, the house plumbing should be inspected and all defects repaired. Then tests could be carried out for underground leakage by the usual methods. Such a procedure as this would give some indication of the proportion which waste from the various causes bears to the total waste, and would serve as a basis for determining whether or not it would pay the city to adopt the available remedies.

An excessive use of water, it must be remembered, is responsible for a financial burden greater than is represented by the cost of pumping or filtering, as it may overtax the capacity of every part of the system. For instance, the per capita consumption is an important factor in the design of the improvements recommended; and the design is based on the assumptions that it will be sufficient to provide capacity in the distribution system for the maximum fire draft, and to maintain a domestic consumption at the rate of 125 gallons a day per capita. These assumptions presuppose the reduction of Ottawa's consumption to a normal figure, the steps for which are strongly recommended by the engineers.

An important question of policy is whether or not it is advisable to meter the domestic services. The larger services for power and manufacturing supplies should certainly be metered; and, moreover, no domestic connection should be permitted to any private fire service unless the service is equipped with a detector meter. Where the domestic services are not metered, a system of house-to-house inspection should be maintained to control the use of water for sprinkling purposes, and to insure that the plumbing is kept in a state of proper repair.

Unfortunately, there is a too general belief that the object of universal metering is to reduce the consumption of water by increasing the cost to the ordinary consumer. This view is entirely incorrect. It is true that the installation of meters has almost invariably reduced the water consumption to legitimate proportions; but this reduction in consumption is due to the restriction of waste on the part of careless consumers. With this waste eliminated, the total cost of providing a supply for a city cannot but be reduced. And, if there are sound reasons, based on carefully collected data, for believing that it would cost the city less to install and maintain meters on the domestic services than it would to supply the waste prevented by these meters, a city should not hesitate to adopt metering because of sentimental or imaginary objections.

The provision for fire draft is as follows:

For the principal business section, containing the risks of greatest value, 35 to 40 standard streams;

For the manufacturing districts, particularly the areas devoted to the lumber industry, 20 to 25 standard streams;

For the closely built semi-commercial section, 15 standard streams;

For the residential sections, depending on the character and proximity of the houses, 5 to 10 standard streams for the worst fires.

For direct pressure, it is desirable that with the usual hydrant spacing, running pressures of 65 to 70 lbs. be maintained in the residential sections under conditions of maximum draft, and 90 to 100 lbs. in closely built semi-commercial and manufacturing sections with no buildings over five stories in height. With a closer hydrant spacing than is generally adopted, fairly good protection is afforded with running pressures of 60 lbs. in residential sections, and 80 to 85 lbs. in semi-commercial and manufacturing sections.

In the scheme of improvements recommended, such capacities have been selected for the new feeders as will ensure satisfactory fire service with the available pressure direct from the hydrants over as large an area as possible. As the average static pressure on the Ottawa system is only 85 lbs., the friction loss from the point of supply to the centre of draft must necessarily be kept within close limits. In fact, it will never be possible to dispense with fire engines entirely for protecting districts with buildings over five stories in height, unless a high-pressure system is provided. And, since over 40% of the Ottawa system consists of 5-inch pipe or smaller, the only way that high local losses of head can be avoided and satisfactory hydrant pressures maintained, is to feed the general gridiron from relatively large mains crossing an area at intervals of from one-quarter to one-third of a mile.

Suitable fire pressures can be maintained for many years in the suburban districts without storage. When the suburban population is largely increased, it will probably be necessary to construct elevated tanks at three or more points to provide storage in the centres of these outlying districts for fire service. The construction of these tanks will maintain suitable pressures without any additions to the proposed feeders. Suitable sites for these tanks are available in Rockliffe for the southern district on the Buchan Road one mile from Billings Bridge, and for the western section somewhere south of Carling Avenue.

Cast iron pipe is recommended for the sizes under 16-inch, and riveted steel pipe for the 30-inch and 36-inch feeders. For the intermediate sizes, the choice between cast iron and steel should be determined by the prevailing prices when the pipe is purchased.

In general, valves are to be placed in the pipes immediately after they leave the main which feeds them, and also immediately after all branches of 12-inch diameter and over are taken off them. Where the branches are small, such as 6-inch and 8-inch, valves are to be placed at least as often as every sixth crossing; and where the

mains run parallel to the long sides of the blocks, valves are to be placed at every third crossing.

Where the new mains are in rock excavation, it will be desirable to replace the present small pipes by the new main in order to take advantage of the easy excavation. It is advisable to do so in any case where the old main is known to be subject to considerable leakage.

It is usually recommended to place hydrants at all street intersections, with a maximum spacing of 500 feet in residential areas and 200 to 250 feet in business districts. No general rule can be indiscriminately applied, however, owing to the difference in the friction losses in pipe of different sizes. For instance, the loss in a 5-inch pipe is about ten times the loss in an 8-inch pipe for the same discharge. Taking into consideration the combined effects of differences of elevation, pipe sizes and dimensions of blocks, the placing of hydrants is plainly a matter which cannot be settled by adhering to a general rule.

A reasonable hydrant spacing in the residential sections, dependent on the distance apart of the mains and the sizes of the smaller street pipes, will be about as follows:

Static pressure.	Distance between hydrants.
80 lbs.	500 to 550 feet
70 lbs.	400 to 450 feet
60 lbs.	300 to 350 feet

In the semi-commercial manufacturing districts, the spacing should be kept down to about 300 feet, and in the principal business districts with buildings up to eight and ten stories high, it will eventually be necessary to adopt a limit of about 200 feet.

The presence of large lumber yards in certain sections of the city constitutes a serious conflagration hazard. If a fire should get beyond control within the yards, the interior hydrants might not be accessible, while the fire might be beyond the range of the adjacent street hydrants. In such an emergency, one or more monitor nozzles mounted on stand pipes in towers at the sides of the yard would be of great service.

The principal business district in Ottawa is at present covered by the "Booster System" which has been lately put into service; and the improvements that have been recommended do not include this district.

It is advised that the city should proceed with the installation of a system of main pipes in sizes ranging from 12-inch to 36-inch. To carry this system to completion will eventually require 30 miles of pipe at an estimated cost, based on current prices for labor and material, of $947,500. Within the total amount recommended, about 13 miles are required for the improvement of the system in the present built-up sections, at an estimated cost of $420,000.

If the "Booster" pumping capacity is increased to meet the demand in the business section, four or five standard fire engines will be sufficient for many years to come; and these can be stationed where they will generally be needed.

The proposed scheme is, in fact, a very desirable one, but it calls for heavy expenditure. Estimates have therefore been prepared for an alternative scheme based on maintaining such hydrant pressures as will permit all streams being taken directly from the hydrants for the small fires, and relying on the use of fire engines in every part of the city for the control of the worst fires. The total estimated cost for this alternative scheme is $776,400 for 34 miles of pipe. The difference in the first cost is $180,100. Taking interest and depreciation at 5½%, this difference in first cost represents an annual charge of nearly $10,000. It is altogether likely, however, that the underwriters would specify eight or ten more fire engines with the alternative scheme than would be required under the original proposition. The annual cost of each fire engine and the incidental equipment has been estimated at $4,000. Therefore, on the basis of ultimate annual cost, including fire engines, the original proposition is, if anything, the cheaper scheme; and as it affords much superior fire protection, it is recommended without qualification.

Referring to the future protection of the principal business district, the "Booster System" should suffice until the end of the year. As an ultimate solution of the problem, this system, with motor-driven pumps, is not favored, as the power for its operation must be purchased at rather high rates. Moreover, the pressure is bound to be limited by what the existing pipes will stand; and this is not sufficient to supply the high-pressure fire streams necessary. Consequently fire engines will still have to be used; and there is also some danger in carrying high pressure on an old system to which connections of all kinds will continue to be made. The additional pressure is dependent upon the operation of a number of check valves, and if any one of these should fail, the pressure would be greatly reduced.

Finally, it is pointed out that no system will effect a reduction in the annual fire losses at all comparable to that which would ultimately result from removing the cause of serious fires by the enactment and enforcement of a good building code embodying the recommendations of the National Fire Protection Association. However, as an efficient fire protection scheme, no other proposition compares at all favorably with the independent high-pressure fire system. That can be made practically free from danger of broken connections to buildings, which records of all great fires have shown to be responsible for an enormous waste of water at the time it was most urgently needed. But, above all, the chief advantage of the system lies in the fact that it provides the means whereby water can be applied to the seat of a blaze in the shortest possible time.

The cost of a high-pressure system in the district covered by the present "Booster System" with pipes below the present system, a hydrant spacing limited to 200 feet, and a pumping plant capable of supplying nine standard pressure streams, each discharging 820 gallons per minute, is estimated at about $290,000.

WAR AND AMERICAN BUSINESS

Authorities are unanimous in the opinion that America will benefit in various ways as the result of the war. They admit that all nations will pay a share of the cost, but generally speaking, they think that the United States, and Canada to a lesser degree, will receive benefits.

Mr. Franklin K. Lane, secretary of the interior at Washington, predicts greater industrial expansion and especially greater mining activity in the United States as a result of the struggle. He says:—"Of importance second only to that of food supply is the supply of mineral products. We have cause for self-congratulation that we are able to feed ourselves. What we possibly have not realized, is that we are nearly as independent in the possession of essential mineral resources as in food products, and that interference with manufacturing caused by interruption of flow of importations of many necessary raw materials, because of the war, may be overcome almost wholly by development of neglected resources in our country."

He added that these resources will be developed if formative legislation be passed.

CLASSES OF PERMISSIBLE EXPLOSIVES.

In order that the users of explosives may know the nature and characteristic component of permissible explosives, and as an aid in the selection of an explosive to meet a specific requirement, the permissible explosives have been arranged in four classes by the United States Bureau of Mines, whose investigations of explosives and their use have been progressing steadily since 1908, with a view to lessening the accidents attending such use. Reports of tests of permissible explosives appear in Bulletin No. 66, from which the following useful information has been taken:—

It is divided into two subclasses. Subclass *a* includes every ammonium nitrate explosive that contains a sensitizer that is itself an explosive. Subclass *b* includes every ammonium nitrate explosive that contains a sensitizer that is not in itself an explosive. The ammonium nitrate explosives of subclass *a* consist principally of ammonium nitrate with small percentages of nitroglycerin, nitrocellulose, or nitrosubstitution compounds which are used as sensitizers. The ammonium nitrate explosives of subclass *b* consist principally of ammonium nitrate with small percentages of resinous matter or other non-explosive substances used as sensitizers.

All of the ammonium nitrate explosives readily absorb moisture from the atmosphere, and great care should be taken in storing them or in using them in damp places. They are not suitable for use in wet mines. If in such a mine a cartridge of an ammonium nitrate explosive is opened and its contents exposed for only a few hours to the damp atmosphere the explosive may deteriorate, and later fail to detonate completely. The ammonium nitrate explosives when stored in well-ventilated magazines for only a few months have shown signs of deterioration, and nearly all explosives of this class after six months' storage at the Pittsburgh experiment station have either failed to detonate or have detonated incompletely. For this reason ammonium nitrate explosives should be obtained in a fresh condition and should be used as soon as possible after their receipt. When fresh, these explosives, if properly detonated, have the advantage of producing only small quantities of poisonous and inflammable gases, and are adapted for mines that are not unusually wet, and also for mines and working-places that are not well ventilated.

Class 2, Hydrated Explosives.—To Class 2 belong all explosives in which salts containing water of crystallization are the characteristic materials. The explosives of this class are somewhat similar in composition to the ordinary low-grade dynamites, except that one or more salts containing water of crystallization are added to reduce the flame temperature. They are easily detonated, produce only small quantities of poisonous gases, and most of them can be used successfully in damp working-places.

Class 3, Organic Nitrate Explosives.—To Class 3 belong all the explosives in which the characteristic material is an organic nitrate other than nitroglycerin. The permissible explosives listed under Class 3 are nitrostarch explosives. They produce small quantities of poisonous gases on detonation.

Class 4, Nitroglycerin Explosives.—To Class 4 belong all the explosives in which the characteristic material is nitroglycerin. These explosives contain free water or an excess of carbon, which is added to reduce the flame temperature. A few explosives of this class contain salts that reduce the strength and shattering effect of the explosives on detonation. Nitroglycerin explosives have the advantages of detonating easily and of not being readily affected by moisture. On detonation some of them produce as large quantities of poisonous and inflammable gases as black blasting powder, and for this reason they should not be used in mines or working places that are not well ventilated.

Rate of Detonation of Permissible Explosives.—The energy developed by the detonation of permissible explosives, like that of other high explosives, depends on the change of the small solid and liquid particles of the explosive into large volumes of highly-heated gases and on the rate of detonation or the rapidity with which these gases are formed. The force exerted by these gases is the means of producing useful effects. The rate of detonation is the governing factor in judging the efficiency of an explosive, and it offers the best single means for selecting explosives suitable to meet the varying conditions of coal mining.

During the conversion of an explosive into solid, liquid, and gaseous products the cooling effect of the walls of the drill-hole tends to lower the temperature of the gases so that the maximum theoretical temperature or pressure is never reached. The more nearly instantaneous the explosive reaction, all other conditions being equal, the greater the volume of highly-heated gases produced, and the more violent the effect.

To meet the varying conditions of coal mining in this country the explosives manufacturers have devised explosives with rates of detonation that range from 4,750 to 14,560 feet (1,447 to 4,439 meters) per second.

Suggestions Useful in Selecting Explosives.—It is hoped that with few exceptions the classification given will serve as a useful guide for comparing the practical value of permissible explosives. It is evident that for certain work in which a shattering effect is desired, as in driving through or "brushing" rock, or in producing coal for coking purposes, the explosive reaction should be rapid. Hence, permissible explosives having a high rate of detonation should be selected. Similarly, for use in soft, friable coal to produce lump or steam coal, selection should be made of a permissible explosive that detonates slowly, and hence gives a more prolonged pressure. In medium hard coal an explosive having an intermediate rate of detonation would be expected to be most suitable, but is not always so. Coals vary in hardness and coal beds vary in the number and position of the joints, partings, shale bands, etc. These facts have to be considered in mining.

An explosive having a very low rate of detonation is not always best suited for mining soft, friable coal, because some of its energy may be lost by its gases escaping through cracks and fractures in the bed. Under such conditions an explosive having an intermediate rate produces the most economical results.

Another factor to be considered in connection with an explosive having a high rate of detonation or the use of a large charge of any explosive is the possible effect on the roof, or the strata overlying the coal bed. Large charges of explosives having a very high rate of detonation cause small fissures that may later necessitate extra timbering to prevent falls in rooms or entries, and thus make the operation of a mine more costly.

It is well known that the pressure developed by the detonation of explosives in a closed space is directly proportional to the charging density; in other words, a 1¾-inch drill-hole loaded with 1¼-inch cartridges will produce on the walls of the drill-hole about one-half as much pressure per square inch as it would if loaded with cartridges of 1¾-inch diameter. A limited experience indicates that explosives having a rapid rate of detonation will yield a larger proportion of lump coal if used

in a hole of larger diameter than the cartridge. Such air-spacing to reduce the shattering effect of an explosive is recommended by the Bureau of Mines, provided the charge is confined with moist clay stemming tamped to the mouth of the drill-hole.

Other less desirable means of reducing the shattering effect of an explosive are the use of an improper detonator, reducing the amount of stemming, using an explosive that is frozen or partly frozen, using an explosive in cartridges of less diameter than those originally tested, and introducing foreign substances between the cartridges of an explosive; but these methods are all dangerous. They not only eliminate the safety qualities of the explosive, but increase the chance of a resultant dust or gas explosion, and should not be adopted.

Results of Tests with Detonators.—Permissible explosives are detonated by means of detonators or electric detonators, which are graded by number according to the weight of fulminating charge. Different types of explosives require detonators of different strength. Detonators are usually fired with fuse. A detonator fitted with a means of firing it with an electric current is called an electric detonator. As an electric detonator is embedded in the explosives with which it is used and is isolated by the stemming, it is the safest means of igniting a charge of explosive in a gaseous mine.

One of the conditions prescribed by the Bureau of Mines for a permissible explosive is that it shall be fired by a detonator, preferably an electric detonator having a charge equivalent to that of the standard detonator used at the Pittsburgh experiment station. It is further required that this charge shall consist by weight of 90 parts of mercury fulminate and 10 parts of potassium chlorate (or their equivalents).

An investigation undertaken by the Bureau of Mines shows that the average percentage of failures of explosives to detonate is increased over 20 per cent. when the lower grades of electric detonators were used instead of No. 6 electric detonators, and over 50 per cent. when compared with No. 8 electric detonators. However, when sensitive explosives were tested under the conditions most favorable to detonation, the same energy was developed irrespective of the detonator used. When tests were made with insensitive explosives under conditions which similate their use in blasting, the energy increased with the grade of the detonator used. For example, the average explosive efficiency of four different explosives was increased 10.4 per cent. by using a No. 6 electric detonator instead of a No. 4 electric detonator, and 14.9 per cent. by using a No. 8 electric detonator. The tests emphasize the importance of using explosives in a fresh condition, and, since this is not always possible, the importance of strong detonators in blasting to offset any deterioration of the explosive through ageing.

The results substantiate these conclusions: (1) That the explosive efficiency of the detonators made by any one manufacturer increases with the grade; (2) that No. 6 electric detonators of four different makes have practically the same explosive efficiency; and (3) each is considered equivalent to the Pittsburgh experiment station standard No. 6 electric detonator for use with permissible explosives in coal mines when the No. 6 grade is prescribed.

Receivers have been appointed for the International Steam Pump Company, a $29,000,000 corporation, by United States Judge Mayer. The receivership was granted in an equity suit brought by bondholders and stockholders and a creditor. The corporation joined in the application. The receiver was authorized to continue the business.

MILD STEEL AND ITS TREATMENT.*

By Albert Sauveur,
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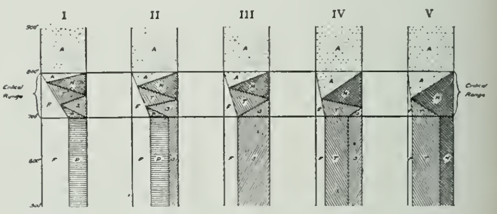
FOR the purpose of illustrating metallographic methods and their teaching we may select as a concrete example the treatment of mild steel, a metal so widely used in machine construction, as, for instance, in the manufacture of shafts, and extensively used, also, for a great variety of steel castings. Such steel may contain some 0.30 per cent. carbon, and should be of good commercial quality; i.e., should contain over 0.1 per cent. phosphorus—preferably not more than 0.05 per cent. of that element—nor over 0.05 per cent. sulphur. According to the treatment it has received it may have a tensile strength varying between 60,000 and 100,000 pounds per square inch, while its ductility, measured by its elongation, may fluctuate between 15 per cent. and 35 per cent. As cast into ingots or other forms this metal shares the shortcomings common to all steel castings—weakness, lack of ductility, and little resistance to shock. These unwelcome properties of steel in its cast condition are due primarily to the structure of cast steel, which is very coarsely crystalline.

It is well known that the properties of steel may be very greatly improved through properly conducted mechanical and thermal treatment, by which its structure



A—Austenite. *M*—Martensite. *T*—Troostite. *S*—Sorbite. *P*—Pearlite. *F*—Ferrite.

Fig. 1.

is modified or refined, and it is the purpose of this paper to describe briefly the various structures mild steel may be made to acquire as the result of work and of heat treatment, and to point out the relations existing between each structure and corresponding physical properties, such as hardness, strength, and ductility.

No explanation of the deep structural changes resulting from certain treatments can be given without reference to the thermal critical range of the steel considered. Fortunately, metallography has so diffused this fundamental knowledge that at the present time there is hardly a metallurgist or metallurgical student ignorant of it. A lengthy description of the occurrence of the critical range of mild steel and of its meaning will not be, therefore, necessary. It will be helpful, however, for the present purpose to illustrate graphically the relations existing between the critical range and the structural changes it is desired to describe.

In Fig. 1 the critical range is represented as covering a temperature zone extending from 700° to 800° C. It will not be necessary, for the aim in view, to take into consideration the existence of two critical points, A_{3-2}

* Lecture delivered before the Mechanical Engineering Society of the Worcester Polytechnic Institute, Worcester, Mass., and published in the Journal of the Franklin Institute.

and A_1, within that range, nor the fact that the points on heating, Ac_{3-2} and Ac_1, occur at temperatures some 25 to 50 degrees higher than the corresponding points on cooling, Ar_{3-2} and Ar_1.

Above its critical range the steel we are studying consists, like all steels, of a solid solution of iron and carbon. In this condition the two constituents are so completely merged that their independent existence cannot be recognized by any physical means; they form a chemically and physically homogeneous mass. Whether carbon in its elemental condition is dissolved in the iron, or whether it is the carbide of iron, Fe_3C, which the iron holds in solution, is here immaterial. We may likewise ignore the various allotropic conditions assumed by iron. The solid solution of iron and carbon stable above the critical range is called "austenite." Whenever it is possible to preserve austenite in the cold to the exclusion of other constituents and to microscopically examine its structure, it is found to be made up of crystalline polyhedra or gains exhibiting in a polished section the appearance of a network, the meshes representing sections through as many grains, and the net itself, junction lines between adjacent grains. The size of the austenite grains increases with (1) the maximum temperature from which cooling starts, (2) the length of time during which the metal was kept at that temperature, and (3) the slowness of its cooling to the critical range. It will not be necessary, nor is it desirable, to further discuss here the probable crystallography of austenite. As to its physical properties, austenite is hard, tenacious, and ductile, but has a low elastic limit.

On slow cooling through the critical range, as shown in Fig. 1, Diagram I., the solid solution of iron and carbon is converted into a mechanical mixture or aggregate of ferrite and pearlite, the latter constituent itself being an aggregate, in definite proportion, of "ferrite" and the carbide Fe_3C, or "cementite." Ferrite and pearlite may be considered as representing the proximate structural composition of the steel, while ferrite and cementite are its ultimate structural constituents. Ferrite, like austenite, and, for that matter, like pure metals and solid solutions in general, is made up of polyhedric crystalline grains, giving rise, on sectional polishing, to network structures. Pearlite is built up after the pattern so characteristic of eutectic and eutectoid alloys, of parallel, alternate plates of its two components, namely, ferrite and cementite. These plates are so thin, however, that a magnification exceeding 200 diameters is generally required for their resolution. Ferrite is very soft and very ductile, but relatively weak, while pearlite is very tenacious and much harder, but also much less ductile.

It is seen that in cooling through its critical range steel undergoes deep structural changes, being converted from the state of a solid solution to that of an aggregate of varying coarseness. So great a transformation must be accompanied by no less momentous alteration of properties, and, indeed, there is little in common between the physical properties of austenite and those pertaining to the ferrito-pearlitic structure existing below the critical range.

Steel with 0.30 per cent. carbon is composed, after slow cooling through its critical range, of 64 per cent. ferrite and 36 per cent. pearlite, as graphically shown in Fig. 1, Diagram I. Bearing in mind the physical properties of its two components, ferrite and pearlite, it will be obvious that mild steel in its ferrito-pearlitic condition, while more tenacious and less ductile than ferrite, will be considerably less tenacious and more ductile than pearlite. Its tenacity, as a matter of fact, should be in the vicinity of 70,000 pounds per square inch, and its elongation in 2 inches should be about 20 per cent. These properties, moreover, will vary considerably in accordance with the coarseness or fineness of the ferrito-pearlitic structure, the finer structure being generally the more ductile. The structure of the steel, after slow cooling through the critical range, will, as a rule, be the coarser, the coarser the austenite immediately before its transformation, and this in turn, as already noted, depends chiefly upon the maximum temperature from which cooling started, the time the metal was kept at that temperature, and the rate of cooling.

It should be borne in mind that the ferrito-pearlitic structure just mentioned, and which corresponds to the end products of the structural transformation taking place within the critical range, results from slow cooling through that range, as, for instance, by allowing the piece to cool within the furnace in which it was heated. On hastening the cooling, structural conditions may be produced corresponding to widely different properties, as will now be described.

The transformation of the austenitic solution into a ferrito-pearlitic aggregation is not sudden, but, on the

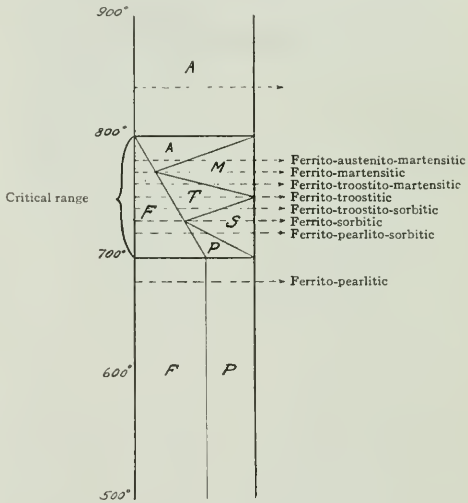


Fig. 2.

contrary, covers a notable range of temperature, while transition constituents are formed within the critical range, as depicted in Figs. 1 and 2. It is intended to show, by means of these diagrams, that, on entering the critical range, the austenite existing above that range is gradually converted into "martensite" with rejection of ferrite, a rejection which continues all through the range; that the martensite, on further cooling, is, in turn, transformed into troostite, which, at a still lower temperature, is itself converted into sorbite; while, finally, pearlite, the end product, forms as the steel emerges from its range. We thus recognize the existence of three so-called transition constituents—martensite, troostite, and sorbite—but it will be unnecessary to enter here into a discussion of their probable nature, a subject which is still, to a certain extent, a controversial matter. Martensite appears to be made up of needles, often forming equilateral triangles; troostite, which consists of irregular ragged or rounded masses; while sorbite exhibits a finely

granular and rather indistinct structure. In regard to physical properties, martensite is very hard and brittle, less hard and less brittle than martensite, while sorbite is less hard than troostite and more tenacious, but less ductile than pearlite.

By referring to Fig. 2 it will be seen that, theoretically at least, seven different structural conditions may be conceived to exist momentarily as the steel undergoes its critical transformation; namely, ferrito-austenito-martensitic, ferrito-martensitic, ferrito-troostito-martensitic, ferrito-troostitic, ferrito-troostito-sorbitic, ferrito-sorbitic, and ferrito-pearlito-sorbitic.

The mechanism of the structural changes depicted in Fig. 1, Diagram I., and in Fig. 2, refer to the changes taking place when the cooling is slow enough to permit

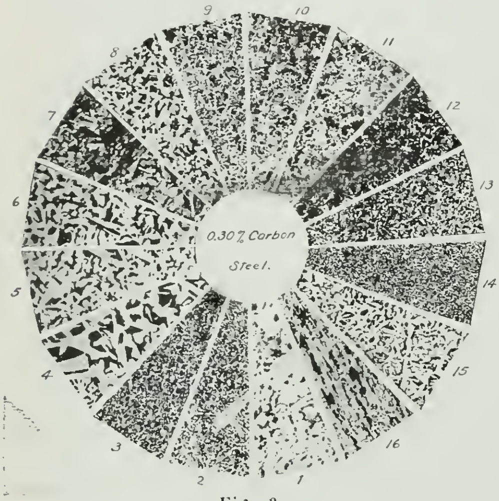


Fig. 3.

Various structures of mild steel (0.30% C.)

1. Steel as cast.
2. Steel cast and imperfectly annealed (remnants of ingotism).
3. Cast steel and properly annealed.

4-8. Heated to various temperatures above critical range for various lengths of time and slowly cooled in furnace. Ferrito-pearlitic structures of different degrees of coarseness.

9-13. Heated above critical range, followed by cooling in air or oil, or heated above critical range, cooled in water or oil and reheated to 600° C. Ferrito-sorbitic or ferrito-sorbito-troostitic Structures.

14. Forged and finished at low temperatures.
15. Forged and finished at high temperatures.
16. Cold worked.

a complete transformation of the metal with final production of a ferrito-pearlitic structure. It will now be shown that through properly regulated cooling the transformation may be arrested at any desired stage in accordance with the physical properties wanted, which may vary from the hardness and brittleness of the quenched metal to the great softness and ductility resulting from very slow cooling. Between these two extreme types lies a great variety of combinations of hardness, strength, and ductility, each set corresponding to a well-defined treatment; hence the science and art of the heat treatment of steel, the importance of which steel-makers and users are only now beginning to fully appreciate.

In Fig. 1, Diagram II., the cooling has been so hastened that on reaching the bottom of the critical range the sorbite had been but partially converted into pearlite, the necessary time for its complete transformation having been denied. This quicker cooling has also prevented a full separation of the ferrite, as indicated in the diagram. The resulting structure may be described as ferrito-sorbito-pearlitic. Large pieces cooled in air often acquire it. Obviously, because of the properties of sorbite, steel in this condition is more tenacious, but less ductile, than the same metal in its ferrito-sorbitic state.

In Fig. 1, Diagram III., is represented the mechanism by which we can conceive the production of sorbite to the exclusion of pearlite, owing to relatively rapid cooling in passing through the critical stage. The steel is now ferrito-sorbitic, while the amount of ferrite it contains is but half the amount of that constituent present in the ferrito-pearlitic metal (Fig. 1, Diagram I.), the necessary time for its complete separation having been denied. In its ferrito-sorbitic condition the steel is decidedly more tenacious, but less ductile, than when ferrito-pearlitic. It is also harder, has a higher elastic limit, and is in a better condition to resist shocks and alternate stresses. A ferrito-sorbitic structure is readily produced in allowing small pieces to cool in air, or larger ones in oil. It may also be obtained by quenching the metal from above its critical range in water or oil, thereby securing a fine structure, followed by reheating to some 600° C. to cause the transformation into fine sorbite of any existing troostite or martensite.

In Fig. 1, Diagram IV., the cooling has been so rapid that, on emerging from its critical range, the metal is caught in a ferrito-troostito-sorbitic state, only a small amount of ferrite, moreover, being present. The metal is now harder and has lost much of its ductility because of the presence of troostite. This structure may be produced by quenching small pieces in oil, or larger ones in water, or by a suitable tempering of hardened pieces.

In Fig. 1, Diagram V., the steel has been cooled so quickly that some martensite, as well as troostite, remains undecomposed on reaching the bottom of the critical range, while but a very small amount of ferrite has had time to separate. In this ferrito-troostito-martensitic condition the metal is hard and deficient in ductility. A structure of this type may be produced by quenching small pieces in water.

The retention of martensite to the exclusion of troostite, and, *a fortiori*, the retention of austenite, is quite impossible in mild steel. While martensitic structures, moreover, are those needed in high-carbon steel for the production of cutting tools, for instance, they are never wanted in low-carbon steel, the structures depicted in Fig. 1, Diagrams I., II. and III., being the only ones of interest to the users of such steel.

Fig. 3 is a composite photo-micrograph showing the various types of structure mild steel may be made to acquire. The legend makes it self-explanatory.

ALASKA RAILWAY SURVEYS.

Good progress is being made with the surveys for the Government railway in Alaska, and it is possible that a preliminary report on the undertaking will be ready for submission to President Wilson late in October or early in November. At the present time parties are working south from the Tanana River, while engineers are working north. Work is also in progress at Portage Bay and Seward and along the line to the head of Cooks' Inlet. The surveys are being made for a route from the coast through the Susnita Valley to the Tanana. This, in general, follows the line of the Alaska Northern Railway to Grand View, 45 miles from Seward, the coast terminal of the railway. Cross-sectioning was started two or three weeks ago on the new route surveyed from Grand View to Turnagan Arm. The coast terminals under consideration at present are Seward and Portage Bay.

Editorial

"*Business as Usual*"

ABOUT A MORATORIUM.

In these strenuous days engineers in Canada are inquiring as to the meaning and scope of a moratorium. It is a temporary and emergency measure and provides for the postponement of the settlement of certain debts. Its duration and the debts to which it shall apply are specified by government proclamation. The time and scope of moratorium laws in various countries, since the declaration of war, have varied considerably. In England the moratorium first was declared for one month to September 4th. Then it was extended another month to October 4th, although of 8,000 replies received to an inquiry of Mr. Lloyd George, Chancellor of the Exchequer, 4,500 were against an extension. A moratorium has not been declared in Canada; but the necessary legislation has been provided for its declaration, if thought necessary. It should be made clear that a moratorium does not cancel, but merely postpones a debt. In England, the press is advising the people to pay their debts whenever possible. That is good advice.

ENGINEERING ENGLISH.

Dr. Chas. H. Snow, Dean of the School of Applied Science of the University of New York, once said in an address to an assembly of young engineers: "The success of the engineer is influenced practically as much by a knowledge of English as by a knowledge of mathematics." Coming from one whose prominence in the advancement of engineering education has marked him as an authority, his audience had, therefore, no occasion to disbelieve.

It must be true that too many engineers do not know how to use good English. The appeal for a remedy comes, not from professional cranks always looking for the impossible and never satisfied with any attainable training, but from reasonable, practical men, at or near the head of their profession—men whose chief desire it is to try to better existing conditions. The appeal cannot, therefore, be disregarded by our engineering schools. It indicates that advancement is needed on their behalf in the interests of engineering education, that perfection has not been reached or the time at hand for a relaxation of united effort in this direction. The subject has been touched upon occasionally in these columns. The motive is by no means a reflection upon the present status of engineering, but it is an endeavor to emphasize that one of the sorest needs in our engineering schools to-day is the need for adequate instruction in English.

By "adequate" is meant sufficient attention being paid to it throughout the entire technical course (and carried even into the graduating thesis) until the student has become proficient in the subject. Every spoken and written report which he is called upon to make should receive proper consideration from the instructors as to its wording and its grammatical construction.

Let us place the facts clearly before our engineering schools and the students themselves. Among the most important deficiencies noted by practising engineers in the technical graduate is his inability to express himself correctly and forcibly in either writing or speaking. The English spoken by many graduates of technical institutions has occasionally been termed atrocious, their letters are awkward, misspelled, and ungrammatical, and their ability to write reports, specifications and contracts is deplorably lacking.

Who is to blame if all this is true? Who is responsible for the lack of good English among our engineers? Why is there a need for engineers to know good English? What is the remedy? These are questions that received some serious consideration at the meeting in Philadelphia some weeks ago of the Society for the Promotion of Engineering Education, an organization to which a great deal of the advancement of engineering education is due.

Three factors within the institutions of learning are concerned, viz.: the department of Engineering, the department of English, and the student. All three, individually and collectively, are to blame. The student, entering from the technical school, is not generally well-prepared, and his weakest subject is, invariably, English. Those technical schools which boast of courses of instruction in English confine it largely to the first year. To the student it appears of minor importance. He is seeking instruction in engineering and studies English as sparingly as possible. The result is that the subject is neglected, and when the stage is reached where it no longer forms a part of the curriculum, it is ignored outright.

The department of English recognizes this attitude of the student towards the subject and makes no attempt to alter it, for the instructor in English is, generally speaking, no more in sympathy with his engineering students than they are with his subject. He knows little or nothing of engineering and makes no attempt to acquaint himself with such a woefully practical study. Is it any wonder that this class of engineering students seek the merest margin of a past in his subject? Does he, with his disinclination to associate with such uncultured students, desire to restrain the delinquent ones for another term under his instruction?

The department of Engineering is disposed to nonchalantly observe that the student is extremely deficient in his English, and that it is regrettable since in the study of engineering there is no time for him to retrace his steps over past studies. Further, the department errs in not recognizing the value of English to the student and in not putting more of it into his work. More than this, the lack of co-operation with the department of English removes the last stepping stone toward retrievement.

It would appear, therefore, that upon the co-operation between the departments of Engineering and English, hinges a matter of gravest importance in the training of the engineering student. It is a mutual problem, and to turn out thoroughly efficient engineers it must be solved.

SURGE TANK PROBLEMS—IV.

BEGINNING A STUDY OF THE INFLUENCE OF A SPILLWAY BUILT IN THE SURGE TANK.

By PROF. FRANZ PRASIL.

Authorized Translation by E. R. Weinmann and D. R. Cooper, Hydraulic Engineers, New York City.

PART 2.

Special Case D—Involving Spillways.

In order to decrease the surge in the surge tank, a spillway may be introduced in the surge tank or in the main conduit. The problem of interest, then, is to determine at what elevation and with what capacity such a spillway should be designed in order that the surge shall not exceed a certain elevation. The case will be investigated under the following assumptions: The spillway is

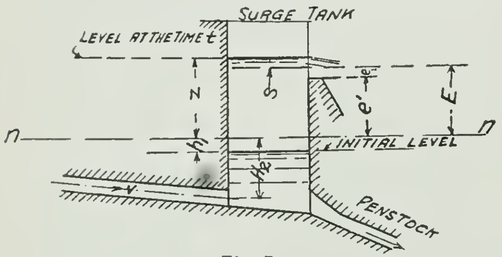


Fig. 7.

attached to the surge tank (Fig. 7). The crest of the spillway is at the distance e' from the static level $n-n$; e' is positive if the crest is above $n-n$ and negative if below. The width of the spillway is b'. The outflow of Q cubic feet per second is suddenly interrupted.

We must take care of several periods of movement. Following a complete shut-down, the water surface in the surge tank will rise to the height of the spillway crest, as is described in case (A).* Next, the rise will continue, but water will flow over the spillway up to a maximum elevation, then decrease to the elevation of the spillway crest. At this moment, the outflow ceases. The movement then takes the form of the case (A), and retains this form thereafter, provided the crest of the spillway is not reached again. Otherwise, the same cycle is repeated or the condition remains one of constant overflow. Therefore, for the first phase the following equations are effective:

$$z = R.e^{-\frac{t}{2T_0}} \sin\left(\beta + \frac{t}{T_1}\right)$$

$$s = -\frac{R}{T} e^{-\frac{t}{2T_0}} \sin\left(\gamma - \beta - \frac{t}{T_1}\right) \quad \text{with } tg\,\gamma = \frac{2T_0}{T_1}$$

The integration constants R and β are obtained for the conditions $t = o$, $z = -h_1$, $s = c_1$. The final value of z is in this period of movement e'. From this we determine the time $t_{e'}$, which is necessary for the rise up to the level of the spillway crest and by means of the second equation we determine the final velocity $s_{e'}$. In the second period of movement now beginning, we have overflow on the spillway, that is, according to the familiar formula for spillways $q = \frac{2}{3}\mu\, b'\, h'\, \sqrt{2gh'}$ where $h' = z - e'$ represents the overflow height and we get

$$\frac{q}{A} = c = \frac{2}{3}\mu\, b' \frac{\sqrt{2g}\,h'^{3/2}}{A} \qquad (82)$$

The introduction of this formula and its derivation in the principal equation (23) would lead to a differential equation higher than the first degree, the integration of which might be accomplished by development in series. For practical purposes, however, an easier but sufficiently exact approximation may be obtained in the following manner:

If we plot the different values of h' computed for the width b' on a rectangular co-ordinate system, the values h' as abscissæ, and the values of q as ordinates (see Fig. 8), we obtain a parabolic curve, passing through the origin. The velocity $s_{e'}$ (which is the final value of the velocity of the surface at the end of the first period of movement) together with A determines a quantity of water $s_{e'}.A$, which is certainly larger than the maximum value of the overflowing quantity during the second period. If we now draw tangents from the point of the quantity curve, which corresponds to $As_{e'}$ and assume as a preliminary approximation that within the heights of

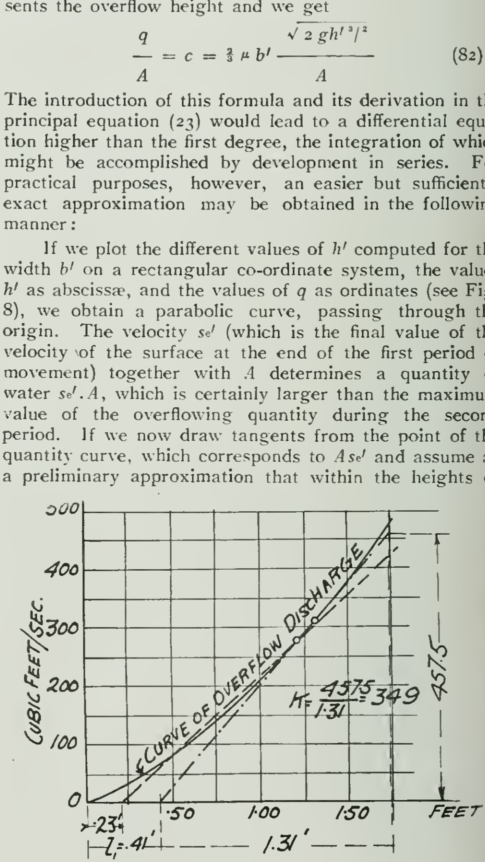


Fig. 8.

the overflow, which corresponds to the intersection of the tangent with the axis of the abscissæ, the overflowing quantity equals zero, which is the same as if we move the elevation of the spillway crest higher up by the same amount, and if we take from this location the water quantity proportional to the height of this new elevation of the spillway crest corresponding to the tangent, then

*See *The Canadian Engineer* for Aug 20, pp. 327-9 and Aug. 27, pp. 368-70.

we get a linear equation for the determination of the water quantity, whereas the differential equation for the determination of the elevations also becomes linear.

The results thus obtained from these equations are naturally only approximate ones, as the overflowing quantities are introduced as too small. The computed values of z exceed the actual values. For practical purposes, this first approximation is generally sufficient, but we have no difficulties using the results of the first approximation for a second computation, drawing the tangent on that point of the overflow curve which corresponds to the maximum value of the elevation found in the first computation and repeating with these results the computation as before. We may use this second approximation in the first computation if instead of the value for the point in the curve, we take a somewhat smaller value, say, $u\,A\,s_e'$, when $u = 0.7$ to 0.8. We use the latter method in the following:

The overflow height, which gives an overflow of $u.A.s_e'$, is determined by

$$h_u = \left(\frac{3}{2}\frac{u}{\mu}\cdot\frac{s_e'A}{b'\sqrt{2g}}\right)^{2/3}$$

The proportional factor k for the linear variation of q is obtained by differentiation of q with respect to k. Therefore:

$$k = \frac{dq}{dh^1} = (\text{as } h' = h_u) = \mu\,b'\sqrt{2g\,h_u} = \sqrt[3]{3/2\,\mu^2\,b'^2\,2g\,u\,s_e'A}$$

k has the dimension $l^2.t^{-1}$, and the value of the abscissa e_1, which is the difference between the true elevation of the spillway crest and that obtained by approximation, is

$$e_1 = h_u - \frac{u.s_e'.A}{k} \qquad e_1 = \sqrt[3]{\frac{19}{12}\left(\frac{u\,s_e'\,A}{\mu\,b'\sqrt{2g}}\right)^{2/3}} \qquad (84)$$

The values are easiest obtained graphically from the curve of the overflow quantities.

Therefore, with e_1 the height of the ideal spillway crest above the static level $n - n$, (that is $E = e' + e_1$) once determined, the computation of the first period of movement must be extended to the elevation E.

We obtain from the previously mentioned formulæ $z_e = E$ and s_e. These are initial values for the second phase, from which beginning we measure the time anew.

$$c = \frac{q}{A} = \frac{k}{A}(z - E) \qquad \text{and therefore } \frac{dc}{dt} = \frac{k}{A}\frac{dz}{dt}$$

and the equation 23 becomes

$$\frac{d^2z}{dt^2} + \left(\frac{1}{T_e} + \frac{k}{A}\right)\frac{dz}{dt} + \left(\frac{1}{T^2} + \frac{k}{A\,T_0}\right)z - E.\frac{k}{A.T_0} = 0$$

Introducing $y = z + m = z - \dfrac{E}{\dfrac{A\,T_0}{k\,T^2} + 1}$ and abbreviating

$$\frac{1}{T_e} + \frac{k}{A} = \frac{1}{T_e^1}; \quad \frac{1}{T^2} + \frac{k}{A\,T_0} = \frac{1}{(T^1)^2} \text{ we get}$$

$$\frac{d^2y}{dt^2} + \frac{1}{T_e^1}\frac{dy}{dt} + \frac{y}{(T^1)^2} = 0 \qquad (85)$$

Corresponding to the investigations regarding the form of the general integral of this differential equation, we must investigate whether the difference

$$\frac{1}{(T_1^1)^2} = \frac{1}{(T^1)^2} - \frac{1}{(2\,T_e^1)^2} \text{ is positive or zero, or negative,}$$

which we obtain by substituting the values of $\dfrac{1}{T_e^1}$ and $\dfrac{1}{(T^1)^2}$

$$\frac{1}{(T_1^1)^2} = \frac{1}{T_1^2} + \frac{k}{2\,A}\left(\frac{1}{T_0} - \frac{k}{2\,A}\right)$$

by which formula the investigation mentioned may be carried out and the corresponding form of the general integral may be used.

The integration constants must be determined with the initial values

$$t = 0; \quad z_e = E; \quad s_0 = s_e$$

The duration of the second period of movement is obtained from the equation for z, which is given by that value of t for which z becomes E once more. If that does not occur in a case of non-periodic movement, for instance, if the spillway crest lies below the level $n - n$, then the duration of the second period of movement is only limited by a new occurrence of any kind of outflow. Otherwise, the final values of the second period are the initial values of a following period, which must be handled the same as the first case. (Case A.)

The method of computation may be shown best by an example. Using the former example, we consider a spillway of 65.7 feet width, the crest of which is at the static level $n - n$. That is, for this assumption $e' =$ zero. The flow of 530 cubic feet per second is suddenly stopped.

From the results of case (A) we get

$$z_e' = 0; \qquad t_e' = 106 \text{ sec.}; \qquad s_e' = +\ .075 \text{ feet/sec.}$$

The velocity s_e' corresponds to the flow in the surge tank at the time t_e' of $q_e' = .075 \cdot 5380 = 404 \dfrac{\text{cu.ft.}}{\text{sec.}}$. For a spillway width of 65.7 feet and for $\mu = 0.6$, we get from the spillway formula $q \dfrac{\text{cu. ft.}}{\text{sec.}} = 208\,h'\,\sqrt{h'}$ and therefore for

$$u\,.\,q_e' = 282 \frac{\text{cu. ft.}}{\text{sec.}} \quad (u = .7)$$

an overfall height of $h' = 1.22$ feet and a proportional factor $k = 3/2\,.\,208\,.\,h_u^{\frac{1}{2}} = 345 \dfrac{\text{sq. ft.}}{\text{sec.}}$ and therefore as the distance of the ideal spillway crest from the static level $n - n$ because $e' =$ zero; $E = .410$ and with the results of case a for $z = E$

$s_e = +\ .073$ feet per second

In order to determine which integral formula to use, we have

$$\frac{1}{(T_1^1)^2} = \frac{1}{T_1^2} + \frac{k}{2\,A}\left(\frac{1}{T_0} - \frac{k}{2\,A}\right) = -\frac{1}{34.6^2}$$

(therefore $\frac{1}{T_2^2} = -\frac{1}{(T^1)^2} = \frac{1}{(2\,T_0^1)^2} - \frac{1}{(T^1)^2}$ is positive)

which shows that we should use the third form of the general integral which is

$$y = \left(R_1\,e^{+\frac{t}{T_2}} + R_2\,e^{-\frac{t}{T_2}}\right) e^{-\frac{t}{2\,T_0^1}}$$

Further, $m = \dfrac{-E}{\dfrac{A\,T_0}{k\,T^2} + 1} = -.354$ feet

$T_0^1 = 14.3$ sec. $T^1 = 51$ sec. $T_2 = 34.6$ sec., so that

$$z = +.354 + 1.33\,e^{-\frac{t}{165}} - 1.27\,e^{-\frac{t}{15.65}}$$

$s = -.00805\,e^{-\frac{t}{165}} + .0810\,e^{-\frac{t}{15.65}}$ which values give the following table:

Seconds $t =$	0	50	100	150	200
feet $z =$	+.41	+1.282	+1.079	+.881	+.746
feet per sec. $s =$	+.073	—.00261	—.0044	—.0032	—.0024

The time of the highest elevation is determined with $s = o$ from equation $o = -.00805\,e^{-\frac{t_1}{165}} + .0810\,e^{-\frac{t_1}{15.65}}$

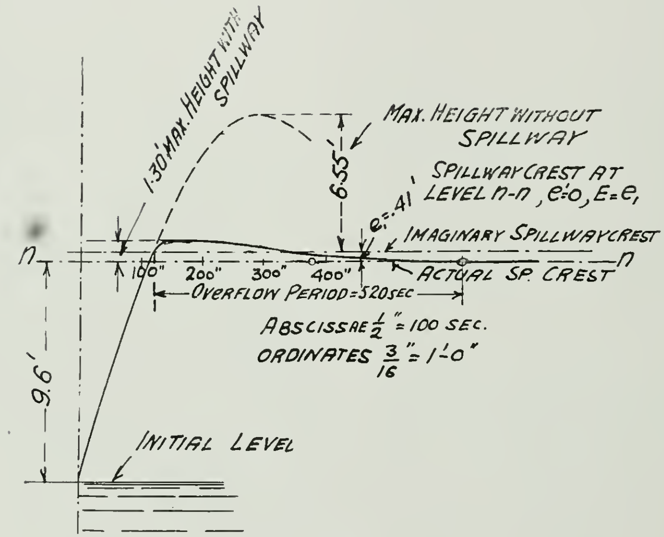


Fig. 9.

$$z = +.354 + \left[R_1\,e^{+\frac{t}{34.6}} + R_2\,e^{-\frac{t}{34.6}}\right] e^{-\frac{t}{28.6}}$$

$$= +.354 + R_1\,e^{-\frac{t}{165}} + R_2\,e^{-\frac{t}{15.65}}$$

$s = \dfrac{dz}{dt} = -\dfrac{R_1}{165}\,e^{-\frac{t}{165}} - \dfrac{R_2}{15.65}\,e^{-\frac{t}{15.65}}$ and for $t = o$

$+.410 = +.354 + R_1 + R_2$; $.073 = -\dfrac{R_1}{165} - \dfrac{R_2}{15.65}$;

therefore, $R_1 = 1.33$ feet and $R_2 = -1.27$ feet

to $t_1 = 40$ seconds and z max. follows:

$$z \text{ max} = +.354 + 1.33\,e^{-\frac{40}{165}} - 1.27\,e^{-\frac{40}{15.65}} = 1.30 \text{ ft.}$$

This water level corresponds to an overflow quantity of 300 cubic feet per second. For the determination of the ideal overflow height and the factor of proportionality, we used the maximum overflow quantity of 282 cubic feet per second. It is therefore shown that the assumption made that $u = 0.7$ is correct. The duration of the overflow period follows from

$$.41 = +.354 + 1.33\,e^{-\frac{t}{165}} - 1.27\,e^{-\frac{t}{15.65}}$$

and is $t_x = 520$ seconds.

And therefore the velocity s_x with which the water level reaches the ideal overflow elevation is:

$$s_x = -.00805\, e^{-\frac{520}{165}} + .0810\, e^{-\frac{520}{15.65}} = -.000346 \frac{\text{feet}}{\text{sec.}}$$

With these initial values the movement in the third period may be determined. Because we assumed that the spillway crest is at the elevation of the static level $n-n$, the overflow period goes further but with smaller fluctuations of water level and overflow quantities.

If the spillway is built not in the surge tank, but in the main conduit, the principal equation requires a supplement. According to Fig. 10, a shaft at the distance L' from the beginning of the conduit is driven down to the conduit with a section A', through which water from the conduit goes over a spillway whose ideal overflow crest is as before the distance E from the static level $n-n$. At the distance L'' is the surge tank with the section A''. In the hydraulic equilibrium with Q_1 cubic feet per second discharge through the penstocks, the water surface in the overflow shaft will be below the static level $n-n$ by the distance $h_1' = n'.v_1$; in the surge tank by h_1'' $(n' + n'')$ v_1. v_1 is the velocity in the conduit of the area a which corresponds to the discharge

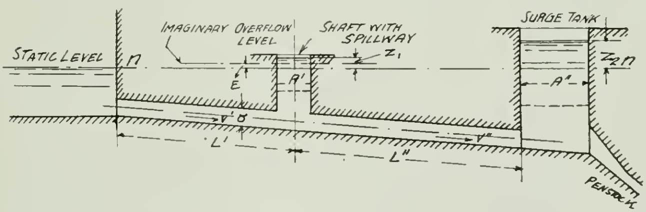


Fig. 10.

Q_1. n' and n'' are the function coefficients corresponding to the distances L' and L''. For flow fluctuations the distance z_1 and z_2 from the static level $n-n$ at the velocities v_1' and v_1'' and the water surfaces in shaft and surge tank will have different levels and there will be overflow in the shaft as soon as the water surface reaches the spillway crest. It is sufficient to carry through the solution of the principal equation for the latter period and to handle the first period as a special case of it.

For the purpose of simplifying the work, we consider only the case of sudden total shut-down. For both parts of the conduit, we get the following movement equations:

$$\frac{L'\, dv_1'}{g\, dt} + z_1 + n'.v_1' = o$$

$$\frac{L''\, .dv_1''}{g.dt} + (z_2 - z_1) + n''\, v_1'' = o \qquad - \qquad (86)$$

The equations which express continuity follow from the consideration that from the upper conduit in a unit of time dt, a quantity of water must flow into the shaft which is equal to the algebraic sum of—

1st—the quantity which flows away in the lower conduit, which is equal to $a.v_1''.dt$.

2nd—the simultaneous filling of the shaft with the quantity $A'.v_1'.dt$.

3rd—the simultaneous overflow quantity $k\,(z_1—E)\,dt$. But the water quantity which flows through the lower conduit in the time dt is also equal to the simultaneous filling $A''v_1''$dt in the surge tank. The following two equations express, therefore, the continuity

$$a.v_1' = a.v_1'' + A'\, s_1 + k\,(z_1 - E)$$

and

$$av_1'' = A''s_2 \qquad - \quad - \quad - \quad - \quad (87)$$

The motion equations and the second equation for continuity reach their values before as well as after the overflow on the spillway. The second equation for continuity is correct for $k = o$, for periods without any overflow. If we consider that $s_1 = \frac{dz_1}{dt}$ and $s_2 = \frac{dz_2}{dt}$ we may, with the aid of the continuity equations, eliminate the velocities v_1', v_1'' and their derivations. We get then two simultaneous differential equations of the second order, from which we eliminate again z_1 and its derivations, whereas for the determination of z_2 we get a linear differential equation of the fourth degree with constant coefficients, the integration of which does not involve any great difficulty.

In order to make the spillway especially efficient, we manage it so that the spillway crest lies below the static level $n-n$, and this in a distance which is equal to or a little less than $h_1' = n'.v_1$. In this case, after the shut-down is finished, a very rapid overflow will occur in the spillway and will continue, and finally there exists a constant flow over the spillway, whereby naturally as much flows through the upper conduit as goes away over the spillway and where the water level in the shaft, as well as in the surge tank lies at a distance under $n-n$, which corresponds to the hydraulic slope necessary for the flow through the upper conduit.

If in this case A' and the spillway widths are small enough with reference to the hydraulic slope, to keep the preceding fluctuations so near the static level of the water surface in the shaft, that the variation of the inflow to the shaft may be neglected, the problem becomes simplified, because the first motion equation drops out and in the first equation for continuity, the values $a.v_1'$ become constant and equal to q.

Considering that $s_1 = \frac{dz_1}{dt}$ and $s_2 = \frac{dz_2}{dt}$, we get from the first equation of continuity (87)

$$A'' \cdot \frac{dz_2}{dt} + A' \frac{dz_1}{dt} + k\,(z_1 + E) = q. \qquad (88)$$

and the second motion equation becomes zero.

$$\frac{L''}{g} A'' \frac{d^2 z_2}{dt^2} + r_2 A'' \frac{dz_2}{dt} + a\,(z_2 - z_1) = o \qquad (89)$$

From this last equation, z_1 and its derivative may be determined and substituted in equation 30c. For the solution of z_2 we get a linear differential equation of the third degree which may readily be integrated. The results of such an investigation are apparent in Fig. 11; we see that at the time of the highest water elevation in the surge tank the height of water flowing over the spillway is directly proportional to the height of the water in the surge tank above the static level, but the quantity of water is greater during the time the level in the surge tank is falling and continues until the level in the surge tank has reached its lowest elevation. The extent of the fluctuations is not only dependent upon the conduit, surge tank and spillway dimensions, but, naturally, also depends upon the area A'. The complete computation of the case would exceed the space available here.

(To be continued.)

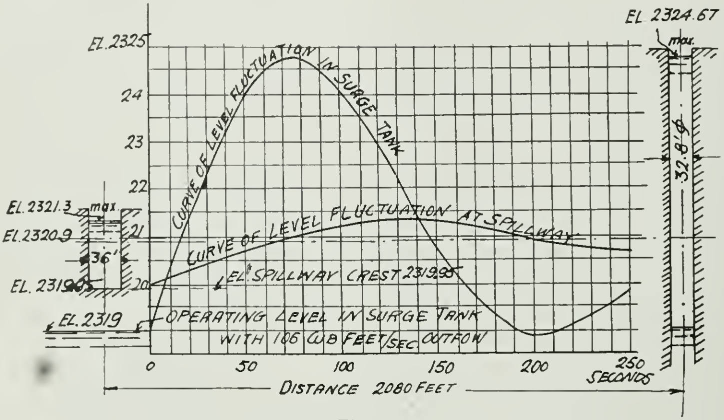


Fig. II.

FIRST INTERNATIONAL ENGINEERING CONGRESS.

THE first international assemblage of engineers to be known as the International Engineering Congress, and to be held at the Panama-Pacific International Exposition, San Francisco, from September 20-25, 1915, will be presided over by Col. George W. Goethals, who has accepted the office of honorary president. The sessions will be held in the new $1,000,000 auditorium now being constructed in the civic centre of San Francisco, the main hall of which has a seating capacity of 10,000. Section meetings will be held in the eleven minor halls in the great convention building.

The International Engineering Congress is to be conducted under the auspices of five national associations, viz.: the American Society of Civil Engineers, the American Institute of Mining Engineers, and the Society of Naval Architects and Marine Engineers, assisted by a committee of eighteen of the foremost engineers of California.

The vast scope of the congress is indicated by the fact that it will be divided into eleven groups of sub-congresses, the reports of which it is calculated will fill eleven large volumes. Chief among these branches will be that dealing exhaustively with the problems worked out in the construction of the Panama Canal, and the influence of the canal on world commerce, commercial trade routes and general transportation problems. Colonel Goethals will have charge of the presentation of all canal topics, and his papers and discussion will carry with them the authority and value of official reports. Aside from general engineering topics, the section devoted to the canal will be treated under 22 heads, as follows:

(1) Col. Goethals' general report; (2) Dry Excavation of the Panama Canal, by Col. Goethals; (3) Dredging the Canal; (4) Terminal Works, Dry Docks and Wharves of the Canal; (5) Meteorology and Hydrology of the Zone; (8) Designs of Locks, Dams and Regulating Works; (9) Methods of Construction of Same on the Atlantic Side; (10) Same on the Pacific Side; (11) Designs of Locks, Walls and Valves; (12) Spillways; (13) Gates of the Canal; (14) Electrical and Mechanical Installation; (15) Emergency Dams Above Locks; (16) Municipal Engineering and Domestic Water Supply in the Zone; (17) Reconstruction of the Panama Railroad; (18) Aids to Navigation of the Canal; (19) Geology of the Canal Zone; (20) The Working Force of the Canal; (21) Sanitation in the Zone; (22) Purchase of Supplies for the Canal.

Following Colonel Goethals' personal reports, each of these topics will be treated by the heads of departments or other attachés who were responsible for that part of the canal construction. These addresses and papers will constitute practically the official technical record of that great engineering feat. It will be published, forming the only printed record of its kind, and for this compilation, interesting to the layman no less than to engineers, credit is due to the exposition congress. Programmes for the other ten sections of the congress are in course of preparation.

Subscriptions are being received daily by local organizations which will act as hosts for this great body, a large proportion of these being from foreign bodies and foreign engineers. The most noted experts of the world in

all departments of engineering work are availing themselves of this opportunity to pass through the canal en route.

PERSONAL.

C. J. GIBSON has received the appointment of town engineer of Bowmanville, Ont.

D. F. McLEOD, former city engineer of New Glasgow, N.S., has become city manager of Lakefield, Fla.

R. C. HARRIS has received the appointment of resident engineer for the Alberta Division of the C.P.R., with office at Calgary.

R. L. HAYCOCK is in temporary charge of the Civic Waterworks and Sewerage Department at Ottawa, in succession to A. N. Beer.

J. D. EVANS, recently chief engineer of the Central Ontario Railway, has been appointed division engineer of the Ottawa Division of the C.N.R.

T. J. BROWN has been appointed a resident engineer and bridge and building master for the C.P.R. company, his office centre to be Cranbrook, Alta.

T. S. LOWE, road foreman of engines for the C.N.R. at Limoilou, Que., has been promoted to master mechanic of the Lake St. John Division, with office at Limoilou.

T. C. HUDSON, formerly master mechanic of the C.N.R. Company at Joliette, Que., has been appointed division master mechanic of the Quebec Grand Division of that system, with office at Joliette.

R. L. DOBBIN, formerly resident engineer on the Moose Jaw water supply scheme during the construction period of 2 years, has been selected to fill the position of waterworks superintendent for the Utilities Commission, Peterborough, Ont.

ARTHUR J. HILLS was appointed in August, general superintendent of the Ontario Grand Division of the Canadian Northern Ontario Railway system, with headquarters at Toronto. Mr. Hills is now in charge of operation, maintenance of way and motive power. He was a graduate of the University of Toronto in 1899.

R. W. McCONNELL, for many years a member of the geological survey staff of the Dominion Government, has been appointed to succeed R. W. Brock, recently resigned, in the office of Director of the geological Survey and Deputy Minister of Mines. Since the resignation of Mr. Brock, Mr. McConnell has been occupying the position of Acting Deputy Minister of Mines.

GEORGE COLLINS, from 1906 general manager and secretary of the Central Ontario Railway, and also from 1903 a director of the same road, has been appointed recently superintendent of the Ottawa division of the Canadian Northern Railway, with headquarters at Trenton, Ont. The former system was taken over this year by the C.N.R., and from 1882 up to that time, Mr. Collins has risen in continuous service with the Central Ontario system.

WILLIAM C. TOMKINS, who received in August the appointment of assistant to the vice-president of the Grand Trunk and Grand Trunk Pacific Railway companies, and who succeeded in that office Martin M. Reynolds, deceased in June, 1914, has been connected with the staff of the G.T.R. system since 1885. Following upon his first position as auditor of pay-rolls came the office of general manager. The next promotion was to the immediate staff of the president, where he became in 1908 secretary to the late Mr. Reynolds, vice-president in charge of finance and accounting. Mr. Tomkins received his recent appointment on August 1, 1914.

B. B. KELLIHER has resigned from his position as chief engineer of the G.T.P. Railway system, due to ill-health. For 30 years Mr. Kelliher has been engaged in railway construction, and has achieved the rank of one of the foremost mountain engineers of his generation; for the last 10 years, he has been actively engaged upon the construction of the G.T.P. railroad; and for 9 years of this latter period, he has been engineer in charge of this great engineering scheme. Mr. Kelliher was a native of Ireland and a student of Dublin University. After serving as an apprentice to a civil engineer in Dublin and being engaged on the surveys for the Mitchellstown and Fermoy and the Galway and Clifton roads, he went to the United States. From 1886 to 1890 he was employed with the Union Pacific Railway; and from 1890 to 1896, was assistant engineer of the Northern Pacific Road on the Cascade and Pacific Divisions. After further experience as division engineer of the Oregon Short Line, he was chosen for the difficult task of locating a line through the mountains of Colorado from Denver to Salt Lake City for the Denver, Northwestern and Pacific Railway, and joined the Grand Trunk Pacific staff on the completion of this work as division engineer at Winnipeg.

OBITUARY.

Mr. John Middleton, a member of a C.N.R. survey party, met death near Lytton, B.C., where he was killed by falling a distance of 70 feet from a ledge of rock.

The death occurred recently of Murdock Lloyd of Toronto, a mining engineer employed at the Tough Oaks Mines, Swastika, Ont. Mr. Lloyd was fatally injured in a boiler explosion.

McGILL GRADUATES AND THE WAR SITUATION.

The following letter has been sent to every McGill graduate:—

At a time like the present, when the destiny of the Empire is at stake, McGill University and its graduates should come forward and do everything in their power to help the common cause. The individual graduate probably does not fully realize the influence the graduates as a whole have in Canadian affairs. Over 5,000 educated men, holding important positions all over the Dominion and elsewhere, are a tremendous power and influence, particularly if their efforts are concentrated on certain fixed objects.

It was felt by the Executive of the Graduates' Society and by the Committee in charge of the Reunion, which it had been proposed to hold in the fall of 1915, that in the present crisis in the Empire something should be done; and it was decided to write a letter to every graduate, asking him to use all his influence towards patriotic ends.

In order to make our influence felt in a definite way it was thought that a fund should be started to which EVERY graduate of the university would contribute. The contribution of each individual would be for the nominal amount of one dollar, which would represent his patriotic vote and the signification of his intention to do everything possible to assist Canada in the responsibility and duty created by the war.

The vote of the McGill graduates will be deposited in cash form to the credit of the Canadian National Patriotic Fund.

You are, therefore, invited to send your cheque, or to enclose one dollar in some other form, to the Treasurer of the fund, Geo. C. McDonald, 179 St. James Street, Montreal.

An immediate response is necessary if this action is to have all the effect that is hoped for from it.

For the Executive,
JOHN L. TODD President.
WILLIAM STEWART. Secretary.

NEW ENGLAND WATERWORKS CONVENTION PROGRAM.

Of particular interest on the program which has been arranged for the thirty-third annual convention of the New England Waterworks Association, to be held at Boston, Mass., from September 15th to September 18th, will be the report by Chairman George C. Whipple, of the committee on statistics of filter operation. This will be the first of its kind in the history of waterworks conventions in America. Other papers of interest will be those read by Frank A. McInnes and Clarence Goldsmith, of Boston, on lessons to be learned from the great Salem fire.

At the "superintendents' sessions" there will be papers by many eminent men of foremost authority on the operation of waterworks plants; while additional committee reports will be given by Frank A. McInnes on "Standard Specifications for Cast-Iron Pipe," by Allen Hazen on "Meter Rates," and by Frederic P. Stearns on "Low Water Yields."

SECOND INTERNATIONAL CONGRESS OF MUNICIPAL EXECUTIVES, 1915.

At the First International Congress of Municipal Executives, London, Eng., it was resolved to grant the request of the American Commission of Municipal Executives, assembled by the Southern Commercial Congress, that the second assemblage of the Congress be held under the auspices of the commission at Washington, D.C., in September, 1915. Senator Duncan U. Fletcher of Florida, president of the Southern Commercial Congress, and chairman Clarence J. Owens of Maryland, managing director of the Southern Commercial Congress and director-general of the American Commission, will have charge of this second international congress, and have already commenced the arrangement of plans to make it the greatest convention of civic leaders municipal officials ever held.

JOINT CONVENTION.

A joint convention is to be held by the American Road Builders' Association and the American Highway Association in 1915, either at San Francisco or at Oakland, Cal., during the Panama-Pacific Exposition, the exact date not yet being determined.

RECENT ELECTION MADE BY THE INTERNATIONAL ASSOCIATION OF TESTING MATERIALS.

The council of the International Association of Testing Materials has elected as members of Commission No. 58 on "Standardization of Methods of Testing and Nomenclature of Road and Paving Materials," Prevost Hubbard, Assoc. Am. Soc. C.E., in charge of the division of roads and pavements for the Institute of Industrial Research, Washington, and lecturer in highway engineering chemistry at Columbia University, New York; and Arthur H. Blanchard, M. Am. Soc. C.E., consulting highway engineer, and professor in charge of the graduate course in highway engineering at Columbia University.

At the recent convention of the Canadian Union of Municipalities, which was held at Sherbrooke, Que., a resolution was unanimously adopted to the effect that Victoria, B.C., should be the centre at which the 1915 assembly of the union should convene.

INTERNATIONAL IRRIGATION CONGRESS.

The Twenty-first International Irrigation Congress will be held at Calgary, Alta., October 5th to 9th, 1914.

COMING MEETINGS.

NEW ENGLAND WATERWORKS ASSOCIATION.—Secretary, Willard Kent, Narragansett Pier, R.I. Annual convention to be held at Boston, Mass., September 15th to 18th.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown, Indianapolis, Ind., Secretary.

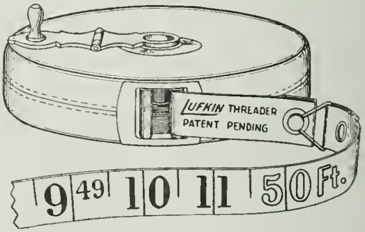
AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Charles Carroll Brown, Secretary, Indianapolis, Ind. Meets at Somerset Hotel, Boston, Mass., October 21st, 22nd and 23rd.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

METALLIC TAPE "THREADER."

The Lufkin Rule Co. of Canada, Limited, Windsor, Ontario, has just put out a patented measuring tape attachment known as a Threader. It is a loop and stud arrangement, by means of which the tape, though securely fastened to the winding drum of the case when in use, can yet be readily detached from it and a new tape as readily attached, no manipulation of the case, case screw or drum being required to do this. Woven tapes are sometimes torn by accident or through long use often become soiled and worn in such a



way that they must be replaced while the case is yet in very fair condition. The case not receiving the same hard use as the tape line usually outwears it, and representing approximately half the value of the outfit it is of considerable importance that it be a simple matter for anyone to insert a new tape in the old case as often as necessary and thus get the fullest measure of use out of the case as well as the tape. Metallic tapes without cases are quite generally stocked by hardware houses, etc., and can always be easily obtained. The attaching is perfectly and easily accomplished by means of the Threader, which will hereafter be furnished with the company's metallic woven tapes without extra charge.

Volume 27. Toronto, September 17, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

THE NATIONAL TRANSCONTINENTAL RAILWAY

GENERAL DESCRIPTION OF THE NATIONAL TRANSCONTINENTAL RAILWAY CONSTRUCTION, DETAILING THE METHOD OF SURVEYS EMPLOYED IN DETERMINING THE MOST DIRECT AND FEASIBLE ROUTE—STAFF ORGANIZATION, ETC.

By DUNCAN MacPHERSON,

Assistant to the Chairman in Charge of Operation, Transcontinental Railway Commission.

An act respecting the construction of a National Transcontinental Railway was assented to by the Dominion Parliament on the 24th October, 1903, which provided for the construction of a line to be operated as a common railway highway across the Dominion of Canada, from ocean to ocean, and wholly within Canadian territory.

This line was, by the act, divided into two distinct parts; the Eastern Division, from Moncton to Winnipeg, to be constructed under a government commission, and the Western Division (extending from Winnipeg to the Pacific Ocean) to be constructed by the Grand Trunk Pacific Railway Company.

The act provides that the Eastern Division shall be built from the eastern terminus, at Moncton, through the central parts of the Province of New Brunswick, and through the Province of Quebec, by the shortest available line, to the City of Quebec; then westerly, through the northern part of the Provinces of Quebec and Ontario, and through the Province of Manitoba to the City of Winnipeg, according to such plans and specifications as may be determined, having due regard to directness, easy gradients and favorable curves.

The commissioners and the chief engineer were appointed by order-in-council August 20th, 1904, and met within a few days for organization. One of the first questions to determine was in regard to the survey work to be undertaken during the autumn and winter on that portion of territory not covered by the Grand Trunk Pacific Railway parties who were out east of Winnipeg, in the direction of, and nearly up to, Lake Abitibi. It was decided to form the territory between Moncton and near longitude 84° into four districts—"A," "B," "C," "D":—"A" from Moncton to the boundary between the Provinces of New Brunswick and Quebec, supposed to be about 290 miles; "B" from the boundary to Clear Lake, about 420 miles; "C" to the provincial boundary between Quebec and Ontario, about 300 miles; "D" to the longitude 84°, about 240 miles.

Soon after these four districts had been formed, the commissioners arranged to take over from the Grand Trunk Pacific the survey parties east of Winnipeg, with their supplies, plans, profiles, etc., and to organize two more districts, "E" and "F," thus covering the whole distance between Moncton and Winnipeg. District "E" extends about 255 miles westerly from the west boundary of "D" to a point about 30 miles west of Lake Nepigon. District "F" extends from this point to Winnipeg, about 385 miles.

The total distance from Moncton to Winnipeg was estimated to be about 1,900 miles, on what was assumed to be the most direct feasible route. The problem to be solved of definitely locating this most direct and feasible route was not an easy one, when it is remembered that, for more than half the distance, the line of general directness ran through an unsurveyed, unsettled and practically unknown region, cut up in all directions with a network of lakes and rivers, many of them not shown on any existing maps and, when so indicated, often found to be entirely misplaced. Our engineers had, therefore, in many cases, to make their own maps as the surveys proceeded and, in all cases, to correct and complete existing maps.

During the autumn of 1904 and the following spring, some 34 survey parties were equipped and sent out; and before the end of 1905 there were 45 parties in the field, consisting of about 18 men each, not counting a large number of men engaged in transporting supplies by canoe and packing in summer and by dog train in winter.

The early survey parties of 1904 were supplied on the time-honored "flour, pork and beans" food basis, and as a result of extreme cold and lack of variety in food, some of them suffered severely from scurvy.

The food schedule was revised on a liberal basis in 1905, with a plentiful assortment of soup, vegetables, jam, etc., with the result that not only was scurvy no longer heard of, but the men being so well supplied with wholesome food worked with much more energy and cheerfulness, showing that seemingly luxurious food proved a real economy.

Each survey party had an engineer in charge, transitman, leveller, topographer, draughtsman, rodman, picketman and 2 chainmen, cook and eight or nine axemen and packers. Each party was given certain governing points to connect and instructed to thoroughly exhaust the possibilities for the most favorable and reasonable direct line between these points. Barometric explorations and compass lines were followed by preliminary lines run with transit, and plans were plotted with 10-ft. contours on a scale of 400 ft. per inch. With these plans and profiles on same scale, projected locations were made on the most favorable lines and afterwards actually run on the ground

and called a first location. These plans and profiles were plotted in the field, and tracings, with reports, sent to headquarters monthly. These reports were carefully gone over by the chief and assistant chief engineers, necessary changes suggested, and instructions issued accordingly. Whenever the head of a party completed what he considered the best possible first location, the engineer in charge was changed and another man given a chance to improve the line by making his best attempt at a revised location. The original head of a party, or a third man, was given a chance to still further revise for a final location. In this way it was found that a healthy rivalry was established and good results obtained. Revision of location is, however, never considered as finished until construction work is well under way; and it is often found, after the line is cleared, that slight changes will effect a very considerable saving. An equation table giving definite values for savings in distance, curvature, rise and fall, etc., was furnished all parties in the field, so that when the estimated cost of construction of any two or more lines was had, the better one to adopt from all points of view could be at once determined.

Maximum Curves.—The maximum curve used is 6° (Rad. 955 ft.) and is only used sparingly where the topographical conditions prohibit an easier radius with reasonable cost. All curves of 1° (Rad. 5,730 ft.) and sharper are connected to their tangents with easy spirals.

The maximum grades decided upon are, so far as the writer is aware, the easiest on any transcontinental line in America, being on tangents of 0.4% = 21.1 feet per mile adverse to the major or eastbound traffic, and 0.6% = 31.68 feet per mile against the comparatively minor westbound traffic. These maximum grades are used sparingly and only for the purpose of avoiding heavy work. On curves, the grades are reduced 0.04 ft. per degree in the index of the curve, so that, on the maximum curve of 6°, the maximum eastbound grade would be 0.4 minus $6 \times 0.04 = 0.16\%$ or 8.44 ft. per mile.

All curves of 1° and over are spiralled at both ends. Vertical curves are used at all intersections of grades. The width of embankments at sub-grade is 16 ft. for banks 16 ft. or less in height; the width of embankments for greater heights, 18 ft. Earth excavations are 22 ft. wide at sub-grade; rock excavations, 20 ft. wide at sub-grade. Slopes of earth embankments are 1½ to 1; rock, 1 to 1. Slopes of excavations are: earth, 1½ to 1; loose rock, 1 to 1; solid rock, ¼ to 1. The depth of ballast is 18 in. between rail base and sub-grade, or 11 in. below the under side of tie 7 in. thick.

The whole line between Moncton and Winnipeg, with the slight exception of short approaches to the Quebec Bridge on 1% grades, was definitely located with the above-mentioned very easy maximum grade; but at one point in New Brunswick, at mileage 146 from Moncton, it was found that, by the insertion of about 12½ miles of 1.1% grade adverse to eastbound traffic, a saving would be made of 17.2 miles in distance, nearly two million dollars in construction, and one and a quarter million dollars in capitalized operating value.

At another point in Quebec, near mileage 286 from Moncton, a similar grade about 10 miles long adverse to westbound traffic was found to effect a saving of 18.8 miles in distance, about half a million in construction, and over three-quarters of a million dollars in capitalized operating value. These possible temporary grades were adopted with the corresponding saving in distance and cost. If the future traffic of the road justifies the expense, these two short lengths of standard grade can be built at any time.

The proviso for directness of alignment proved a very wise precaution; as, in the Province of New Brunswick especially, the people inhabiting the fertile, well settled St. John River Valley very naturally desired to secure the advantage which would accrue to their section of country by the construction of a transcontinental railway. The fact that this would unnecessarily lengthen the line by 29 miles, a most important factor on a through route, did not appeal to them as strongly as to the inhabitants of the more western provinces anxious to secure the best possible outlets for the rapidly increasing volume of freight from the great wheat field of the west. Fortunately, our engineers were able to prove that the direct line would not only be much shorter and effect a great saving in operation, but also that the total cost of construction would be very considerably less. An additional factor in favor of the direct line was the opening up of new territory not hitherto possessing railway facilities; whereas, the St. John Valley is already served by the Canadian Pacific, and to some extent by the Intercolonial Railway.

The surveys being well advanced for some distance east of Winnipeg and west of Quebec, tenders were called, closing on the 12th March, 1906, for 150 miles of line from the north side of the St. Lawrence at Cap Rouge, westward, and for a steel viaduct 3,000 ft. long, 150 ft. high, across the Cap Rouge Valley; also for 245 miles from near Winnipeg to Peninsula Crossing, near the proposed junction with the Fort William branch of the Grand Trunk Pacific Railway. This branch line had been under construction for some time; and the intention was, as soon as it and the portion of the main line between the junction and Winnipeg were completed, to start operating between Fort William, Winnipeg and the west, thus giving another outlet to the Great Lakes from the western wheat fields.

The summer of 1906 was a busy one in railroad construction all over the continent of North America, the result being that good men were almost impossible to obtain, so that progress was not as fast as was anticipated on the two first main contracts let. The financial depression in 1907 proved, in some ways, a blessing in disguise to railway contractors; as only roads which were strong financially were able to proceed with any new construction; also, men were more plentiful. From time to time as the final location was completed on different sections, new contracts were let until, on October 29, 1908, the last contracts were let on Districts "D" and "E". In the summer of 1908, 21,000 men were at work on the various contracts between Moncton and Winnipeg.

The originally estimated distance of 1,900 miles between these points had been reduced gradually by repeated revisions of location at various points to a distance of 1,804.8 miles. This distance is 261 miles less than the shortest distance over any other combined railway between Moncton and Winnipeg. The distance between Winnipeg and Quebec City over the Transcontinental Railway, will be 1,351 miles, which is 215 miles shorter than the shortest existing line, and the grades are so much more favorable that engines of equal capacity could haul nearly twice the load on the former line than they could on the latter.

Transportation of grain by water has always been much cheaper than by rail, but the latter has been slowly and surely cheapening until at the present time, when the easy gradients and tremendously powerful locomotives of modern lines will make a combination of land difficult to excel, or peradventure, to equal on water.

The distance from Winnipeg to Quebec, via rail to Fort William, and lake, canal and St. Lawrence River to

Quebec, is 1,771 miles, involving five trans-shipments of wheat. The distance on the Transcontinental Railway will be 1,351 miles, and, as the maximum eastbound grade is 21.12 feet per mile, compensated for curvature, a heavy modern locomotive is capable of hauling on this grade a gross load behind the tender of 4,290 tons. Assuming the tare 33⅓% of gross load, the net paying load would be 2,860 tons, equal to 95,333 bushels of wheat in one train. If we assume the earnings of such trains to be $4.40 per train mile (the average earnings of the Canadian Pacific Railway freight train miles for 1913 were $2.99 for an average of 440 tons per train), we find the cost per bushel over the 1,351 miles between Winnipeg and Quebec to be 4.25 cents. The lowest rate that the writer is aware of having been in force from Fort William to Montreal, via the lake, canal and St. Lawrence River, a distance of 1,216 miles, was 4 cents per bushel in 1908. This four cents per bushel for 1,216 miles would be equivalent to 4.44 cents for 1,351 miles, so that at 4.40 per train mile, the engines above referred to could haul grain on the Transcontinental eastbound from Winnipeg to Quebec for 0.19 cents per bushel cheaper than the cheapest existing water route could haul it the same distance, and 10.86 cents per bushel cheaper than the present combined rail and water rates between the two points in question. In brief, at about one-quarter the present rail and water rate. It would appear that the days of the absolute supremacy of water transportation were in danger of at least a partial eclipse.

The comparative values of Transcontinental Railway and existing lines between Winnipeg and Quebec would be as follows:

From Winnipeg to nearest Atlantic seaport (Quebec) via Transcontinental Railway, is 1,351 miles (allowing 6 miles from north end of bridge to city) or 215 miles shorter than the shortest existing railway. Assuming the operation of only 6 daily trains each way, and the cost of a train mile $1.50, this shortening in distance alone is worth $35,312,500 in operating value capitalized at 4%, without taking into account the enormously increased earning value of the whole line due to its extremely low grades; but the maximum eastbound grades on Transcontinental being 0.4%, and westbound 0.6%, as against 1% on existing lines, not only can freight trains of about twice the capacity be hauled on former, as compared with the latter, but with the shorter distance they would make the trip in about 12 hours less time. Omitting consideration of this saving in time, which is in itself of considerable value, the operating values of the N.T.R. and existing lines can be fairly compared as follows:

Yearly cost of operating 20 daily trains on existing lines over 1,566 miles = 1,566 × 2 × 10 × 365 × $1.50	$ 17,147,700
Yearly cost on Transcontinental, 1,351 miles, is based on 12 daily trains, because they can haul the tonnage of 20 trains on existing lines = 1,351 × 2 × 6 × 365 × $1.50	8,876,070
Yearly saving in operation by N.T. Railway.	$ 8,271,630
Capitalized at 4%	$206,790,750

This $206,790,750 is only the increased earning value of the Transcontinental Railway between Winnipeg and Quebec over a line with 1% grades 215 miles longer.

As the whole line from Winnipeg to Moncton is expected to cost $161,300,000, of which about $40,000,000 was expended east of Quebec and $121,300,000 west of Quebec, it would appear, therefore, that even with moderate traffic the Transcontinental is capable of earning good interest on its enormous cost.

Owing to the comparative inaccessibility of parts of the line, the last 300 miles of it were not actively under construction until the end of 1910; but by that time it was covered with workmen, rock drills, steam shovels, and all the necessaries of modern railway construction.

In order to keep check on the rate of progress of the work, the writer introduced on this line percentage forms of reports, being modifications and extensions of somewhat similar forms in use on the Canadian Pacific Railway. This form is returned monthly by the division engineers, through the district engineers; and it is then graphically plotted on a diagram which shows at a glance, not only the percentage done during the month on grading, ballasting, and all the other items of construction, but also shows the percentage done to date under each of these headings and the percentage done of the whole work in each main contract. This form of report has been found invaluable as an aid in answering requests for information from the House of Commons when in session, and for compiling our annual reports.

Our engineering organization consisted of a chief engineer, assistant chief engineer, bridge engineer, district engineers—each in charge of a district from 250 to 400 miles long—division engineers—each in charge of from 40 to 50 miles—and resident engineers—each in charge of 10 to 15 miles.

The final connection of track between Moncton and Winnipeg (except for Quebec Bridge) was made in November, 1913, and the car ferry for bridging this gap, capable of carrying 27 loaded freight cars, or a passenger train, has already arrived at Quebec.

The completion of ballasting, buildings, etc., has been pushed vigorously this season, so that it is confidently expected to have the whole line ready for transporting this season's wheat crop in October, 1914.

NEW FOREIGN TRADE COMMENCING IN AMERICA.

Gleaned from the press and from consular offices, the following items of a few of the immediate needs of China, South America and Europe should aid American manufacturers. A consular report from Rome, Italy, states that owing to all steel material for the ordnance of the ships under construction for the Italian navy being tied up in France or Germany, the navy is looking to the United States to furnish the material; and investigations have already been made among the American steel plants. One hundred and fifty thousand tons of steel are wanted. A telegram from the American minister at Caracas, Venezuela states that cement is needed in that country.

The export department of the United States Steel Corporation has received a contract for 100 miles of 80-lb. steel rails to be shipped to South America. At present Shanghai, China, is experiencing a building boom and the demand for building materials is constantly increasing, according to a consular report. At Hankow, China, there is an opportunity for the establishment of an American firm carrying a full-sized stock of building materials.

Small orders for the export of fabricated steel and machinery are already being received by American manufacturers as a direct result of the effect of the European war on industry in England and Germany. Inquiries are coming to hand at a rate that bids fair to act as a forerunner of the anticipated development of export trade, not only with South America, Africa and Australia, but with England and with Scandinavian and Mediterranean countries.

DESIGN OF NEW AND RELIEF SEWERS.

In several previous issues (August 27th and September 3rd) of *The Canadian Engineer* articles appeared dealing with special phases of the new sewerage plan for the City of Cincinnati. The sewerage investigations formed the subject of a very complete report recently issued. Another portion of it that contains an abundance of information for sewerage and municipal engineers is based on that portion of the work in connection with the design of new and relief sewers, which is chosen as the subject of this article. This work was under the direction of Mr. F. J. Van Hook, from whose report we present the following:

A critical study of the existing sewerage system of Cincinnati was made with a view to recommending such improvements as would provide relief in districts subject to flooding in times of storm, and such new sewers as may be required for districts not provided with sewerage facilities. In the design for the new sewers recommended the combined system of sewerage was employed. Since the quantity of house sewage is relatively very small, as compared with the storm water-flow, it is evident that the problem presented is one of storm sewer design.

Rainfall and Run-Off.—Before taking up the detailed studies for sewerage improvements, analyses were made of the several factors controlling the determination of the amount of surface drainage for which provision should be made in the design of storm sewers. The factors considered are as follows: (1) Intensity of rate of rainfall. (2) Relation between rainfall and run-off, or the proportion of rainfall which immediately reaches the sewers. (3) Extent and shape of the area to be drained. (4) Surface slopes.

Many attempts have been made to establish relations between these factors and to express them in formulæ. As there appeared to be no method which had been regularly and continuously used in Cincinnati for the determination of the amount of storm drainage for which sewers and drains should provide, a review was made of the more commonly accepted methods and formulæ to ascertain if any one of these was applicable to local conditions.

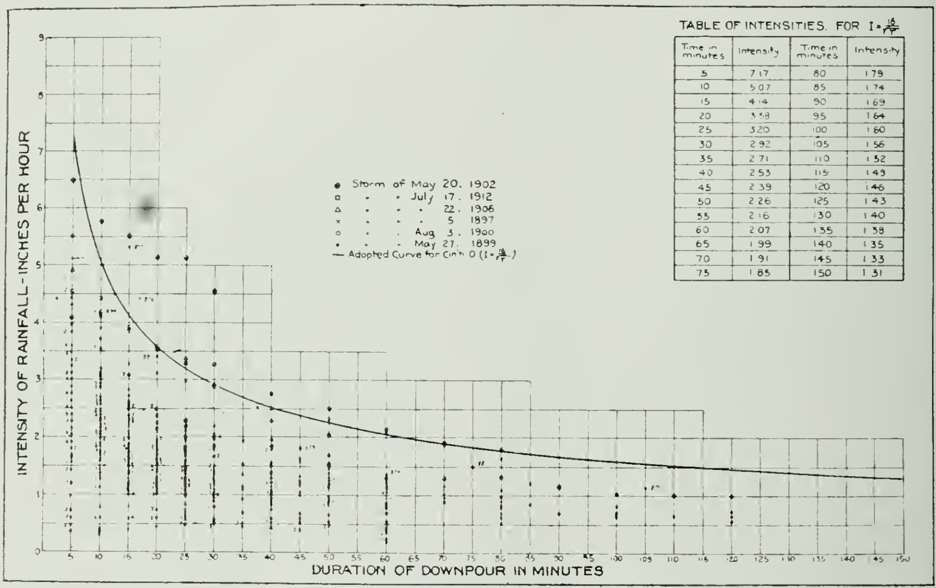
Table I.—Rates of Precipitation Which Fix Lower Limit of Excessive Precipitation in Storms Since 1904.

Period (minutes).	Rate (inches).	Period (minutes).	Rate (inches).
5	0.25	40	0.60
10	0.30	45	0.65
15	0.35	50	0.70
20	0.40	60	0.75
25	0.45	80	0.80
30	0.50	100	0.90
35	0.55	120	1.00

Most of the run-off formulæ are based on conditions existing in the particular city or locality for which they were derived and it is, therefore, evident that these should not be used excepting under similar conditions. Also, some formulæ are made dependent upon an adopted maximum rate of rainfall which is kept constant. On the other hand, the use of the so-called "rational" method of analysis through the introduction of the element of time permits of a varying rate of rainfall immediately dependent upon the area, shape and slope of the territory to be drained.

Also, on account of the unusual topographic features prevailing in Cincinnati, producing numerous small drainage areas with comparatively steep surface slopes in the outlying districts and flat slopes in the older portions of the city, it is important that the proper rainfall intensity and run-off for short periods of time should be accurately determined.

In view of these facts, it was concluded to adopt the "rational" method in determining the amount of storm



Time in minutes	Intensity	Time in minutes	Intensity
5	7.17	80	1.79
10	5.07	85	1.74
15	4.14	90	1.69
20	3.58	95	1.64
25	3.20	100	1.60
30	2.92	105	1.56
35	2.71	110	1.52
40	2.53	115	1.49
45	2.39	120	1.46
50	2.26	125	1.43
55	2.16	130	1.40
60	2.07	135	1.38
65	1.99	140	1.35
70	1.91	145	1.33
75	1.85	150	1.31

Fig. 1.—Relation Between Intensity and Duration of Rainfall, Cincinnati, 1871 to 1912.

drainage for which provision should be made. This formula may be expressed as follows:

$$Q = A\,C\,I$$

in which,

Q = the discharge in cubic feet per second.
A = the area drained in acres.
C = the ratio of run-off to rainfall.
I = the intensity or rate of rainfall during the period of concentration.

The procedure in this method of analysis is as follows:

(1) The time is first approximated by observing the surface or sewer slopes, estimating the sizes of pipe necessary and, assuming that they run full, determining the velocities. The time necessary for flow from the remote portions of the drainage area under consideration can then be calculated.

(2) With the time factor approximated, the intensity or rate of rainfall is determined from the rainfall intensity curve or equation.

(3) The run-off coefficient C, or reduction factor, is then determined by estimating the probable future increase in the percentage of impervious area.

(4) Having determined the rate of rainfall and the run-off coefficient, the discharge may be calculated and the sizes and grades of sewers determined in the usual manner. A closer estimate can then be made of the time factor and, if found necessary, a second calculation made of the sizes and grades.

Intensity or Rate of Rainfall.—The use of the "rational" method of analysis requires a thorough study of the local rainfall records for the purpose of determining a rainfall intensity curve which shall define the limit of excessive storms for which provision should be made in the design of storm sewers. By means of this curve the rate of rainfall can be determined for any period of time.

Rainfall Records.—Rainfall records for Cincinnati have been kept by the U.S. Weather Bureau from 1871 to date. Through the courtesy of the local forecaster of the weather bureau, these records have been examined and data relating to significant storms taken from them and made available for use as the basis of the rainfall studies.

The U.S. Weather Bureau published in 1912 the total monthly rainfall for each year from 1871 to 1912 inclusive, together with the total annual precipitation and the mean precipitation for each month, and for each year. These data were available but were not of particular use in the rainfall studies made in connection with the sewerage problem.

Unpublished Data Furnished by U.S. Weather Bureau.—(1) The records of heavy rainfalls having a total precipitation of 1.5 ins. or more, in 24 hours, or having a rate of 1 in. per hour for shorter periods, with extracts from the daily journal, from 1871 to 1897, were tabulated.

(2) The hourly amounts of precipitation during the storm of march 12 and 13, 1907, during which 7.19 ins. of rain fell during 48 consecutive hours were tabulated. While this was an exceptionally heavy rainfall extending over a long period of time, it did not give the very high intensities which make it of great significance in the problem of sewer design.

(3) The accumulated amounts of excessive precipitation from July 1, 1897, to July 31, 1912, for short periods of time from 5 minutes to 120 minutes were tabulated. From 1897 to 1904 the amounts were tabulated for each 5 minutes for storms in which the rate of precipitation equalled or exceeded 0.25 in. in any 5 minutes or 0.75 in. in 1 hour. After 1904 the amounts are tabulated for all storms during which the rates of precipitation equalled or exceeded in any period those given in Table I.

The data mentioned in the preceding paragraph were compiled from the charts taken from the automatic recording rain gauge at Cincinnati. These are the storms which form the most reliable basis for studies of intensity of precipitation and, while the older records furnish some valuable data the chief reliance must be placed on the records of the last 15 years.

Re-Arrangement of Data Furnished by Weather Bureau.—The table mentioned under paragraph 3, above, gives the amount of accumulated rainfall by periods ranging from 5 to 120 minutes, from the beginning to the end of excessive precipitation but does not give the maximum rainfall for each length of period indicated. A table was

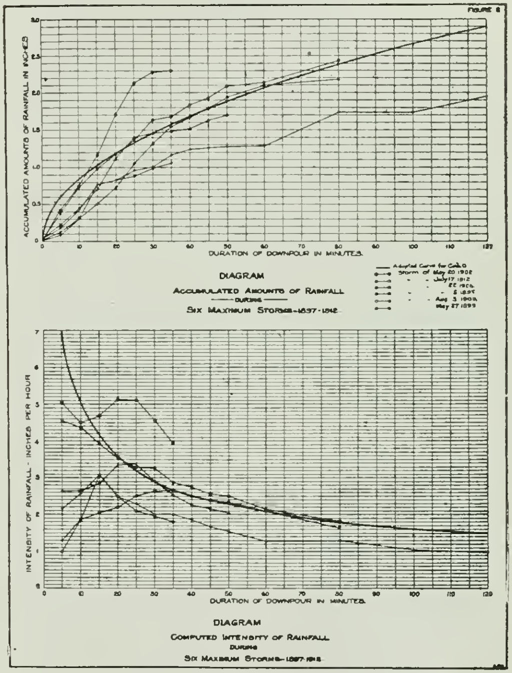


Fig. 2.

prepared to give the maximum precipitation for periods of from 5 to 120 minutes' duration. In this table the precipitation given for any specified period was the maximum amount falling during a period of such duration. For example, during the storm of September 13, 1910, the maximum quantity of precipitation during any 10 minutes was 0.41 in., whereas the amount which had fallen at the end of the first 10 minutes of excessive precipitation was but 0.21 in., and the former figure does not necessarily include the latter.

The intensity of precipitation was calculated for short periods of from 5 to 120 minutes for each of the significant storms, the result of said calculations being tabulated. These calculations are based upon the maximum quantity of precipitation during the period specified, as indicated by the data in the tabulation mentioned in paragraph 3. The intensity tabulation includes data re-

lating to 93 storms occurring from July 5, 1897, to July 17, 1912. These data form the basis of the studies which have been made to determine the rate of rainfall for which provision should be made in designing sewers and upon which the rainfall curve hereinafter described has been based.

An examination of all records from May 31, 1871, to July 17, 1912, indicates that there have been 63 storms during which the intensity for some period of time was equal to or in excess of 1 in. per hour, and which produced a total rainfall of at least 0.5 in. during the stated period. The data relating to these storms are compiled in a table, entitled "Intensity of Precipitation During Excessive Storms at Cincinnati," and are arranged in order of descending intensities.

In another table entitled "Excessive Rainfall at Cincinnati," there have been compiled the data relating to all storms of excessive total rainfall or excessive intensity, arranged by months. This table indicates that there have been 92 storms since 1871 when the total rainfall amounted to or exceeded 2 ins., or, where the intensity amounted to or exceeded 1 in. per hour for a period in which the precipitation was 0.5 in. or more. There are given in this table the total precipitation for the whole storm, as well as the amount of precipitation, duration and intensity of precipitation during the period of excessive rate of rainfall.

Diagram of Intensity and Duration of Precipitation.—On Fig. 1 the rate of precipitation of each of the excessive storms for periods of from 5 to 150 minutes has been plotted as has also a curve which marks approximately the upper limit of all storms, except that of May 20, 1902, which was of extreme intensity. It is unfortunate that records showing the rates of precipitation are not available for a period of more than 15 years, but the fact that there have been during this time four storms in which the intensity was practically that shown by the curve, indicates that such storms may occur at intervals of from 3 to 5 years. It has been deemed wise to use in the design of the storm sewers, a curve, represented by $i = \frac{16}{T^{0.6}}$ to include these storms, in which i = intensity of precipitation and T = duration of period under consideration. It has not, however, been deemed wise to include the extreme storm of May 20, 1902, which, based on present records, is not likely to occur oftener than once in 15 years and probably will recur at even greater intervals.

This curve is higher than the curves which have been adopted in several other places, but appears to be fully warranted by the rainfall data accumulated in Cincinnati since 1871 and particularly in view of the rainfall data secured by means of the automatic recording rain gauge of the U.S. Weather Bureau during the last 15 years.

The topography of Cincinnati is such that the time of concentration in most of the sewers is very short, this making that part of the curve dealing with intensities for periods of from 5 to 30 minutes rather more important than that part dealing with intensities of periods greater than 30 minutes.

The intensities indicated by the curve have not been exceeded materially except by one storm, that of May 20, 1902. The storm of July 17, 1912, slightly exceeded the intensity indicated by the curve but the excess lies well within the limits of unavoidable errors.

In Fig. 2 the rainfall records for six maximum storms from 1897-1912 have been platted on two diagrams, the upper diagram showing the accumulated amounts and the lower diagram the actual intensity of precipitation for the successive periods of time. For purposes of comparison, the curve adopted for use in designing sewers has been shown on these diagrams.

Ratio of Run-Off to Rainfall.—Having determined upon the intensity or rate of rainfall for which provision should be made, the next factor of importance is the determination of the proportion of the rainfall which immediately reaches the sewers in any section of the city. This proportion of the ratio of run-off to rainfall is relatively difficult of determination, not only for present conditions but also for future development. Some of the factors which influence its determination are: the extent of improvement and development within the area, the surface slopes, character of the soil, frequency of storm inlets as well as the capacity of the tributary or lateral sewers to carry off the storm water.

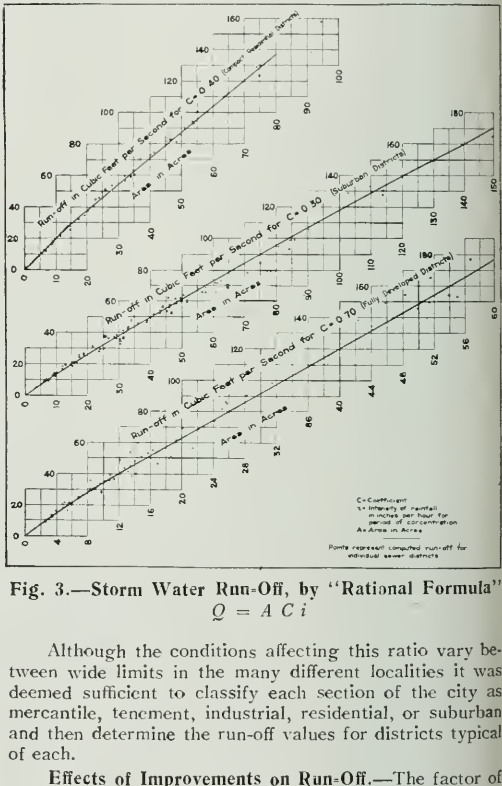


Fig. 3.—Storm Water Run-Off, by "Rational Formula"
$Q = A\ C\ i$

Although the conditions affecting this ratio vary between wide limits in the many different localities it was deemed sufficient to classify each section of the city as mercantile, tenement, industrial, residential, or suburban and then determine the run-off values for districts typical of each.

Effects of Improvements on Run-Off.—The factor of greatest importance is the extent to which each of these districts is improved and developed by buildings and pavements. To furnish the data bearing on this point surveys were made in the following districts which were selected as representing typical conditions:

(1) Mercantile district. (Walnut Street Sewer.)

(2) Tenement district. (Densely populated, Clark Street Sewer.)

(3) Combined industrial and densely populated district. (Bader Street Sewer.)

(4) Residential districts. (Walnut Hills, Bloody Run Sewer.)

In each of these districts the area covered by roofs, pavements, walks, yards, lawns, and the undeveloped ter-

ritory were ascertained and to these different classes of surfaces run-off values* were applied and a final value determined upon for that district. The nature of the results obtained by these surveys and computations are shown in Tables II. to V.

Sewer Gaugings.—In addition to analyses of the surfaces of these selected typical districts, and the determination of the proportions of pervious and impervious areas, gauging stations were established in the sewers draining these districts, for the purpose of furnishing data which will serve both as a check on the method of analysis used and the relation between the rate of rainfall and the storm flow in the sewer.

To gauge the storm flows in the mercantile district an automatic clock-recording sewer gauge was placed in a side chamber of a sewer in that district. This gauge registers on a chart the depth of water flowing in the sewer during the progress of a storm. At the same time records of the rainfall are obtained by the government rain gauge located on the postoffice building, which lies within the area drained by this sewer. For the residential district a similar sewer gauge was placed in a side chamber of a sewer in that district. In order to obtain the rainfall records within this drainage area, an automatic tipping bucket rain gauge of the Frieze type was installed by the city.

The storm flow in the Clark Street Sewer, in the tenement district, is measured by means of a gauge of the maximum or flood-flow type, consisting of a staff with small bottles attached on either side which are filled as the water rises in the sewer, the highest bottle filled registering the maximum depth of flow. Other gauges of the same type were set at manholes in six other sewers.

These gauges have been maintained since June 1, 1913, but the records obtained thus far have been too meager to warrant any deductions, especially since the storms of the last five months have been of very moderate intensity and of short duration. To obtain conclusive results from storm flow gaugings it is necessary that they be extended over a long period of time in order that a sufficient number of records of storms of great intensities and sufficiently long duration may be secured. Such records will be of the greatest importance in the design of storm sewers for Cincinnati, and it is therefore to be hoped that these gaugings may be continued for several years. Fig. 4 shows details of one form of gauging chamber.

Run-Off Diagram.—Before the analyses of the improvements in typical districts were completed designs were in progress for new and relief sewers in the various parts of the city. In these designs the rational method was used and the following coefficients were adopted for the determination of the amount of run-off to be provided for:

C = .30 for suburban districts where little future development may be expected.

C = .40 for residential districts.

C = .70 for densely populated and completely developed tenement and small block districts.

The amounts of run-off which were determined in the course of the numerous designs have been plotted and curves projected by the use of which run-off quantities can be determined directly for any area in question without otherwise laborious computation work. These curves, shown on Fig. 3, have been used for the later preliminary studies. For completely developed commercial districts higher coefficients should be used.

Method of Study.—With the completion of these preliminary studies, and decision as to method of design, the preparation of plans for new and relief sewers was at once started, the problems generally recognized as most urgent being attacked first.

Data Available.—The complaints received were used as an index to the localities or districts in most urgent need of relief sewerage. For the study of these districts it was necessary to have at hand the records of existing sewers, as well as the proper portions of the topographic map. In so far as possible the two branches of the Division of Sewerage Investigations which were carrying on

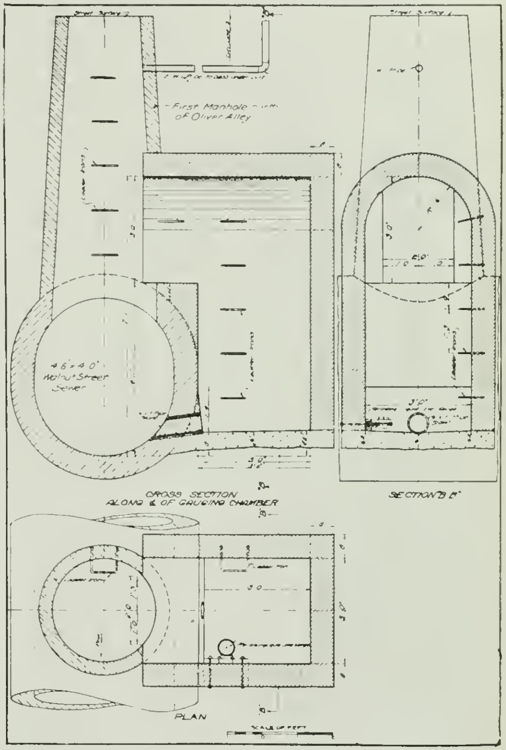


Fig. 4.—Details of Typical Gauging Chamber.

these surveys, directed their efforts in such a way as to secure the necessary data as soon as possible. But the fact that such data were not at once available in the various parts of the city requiring sewerage plans has been a handicap to the progress made in these relief investigations.

Procedure.—To determine the cause of cellar floodings or other defective drainage and to recommend the most suitable relief measures, necessitated an exhaustive study not only of the sewers in the immediate vicinity of the floodings but in the adjacent territory as well, inasmuch as it was often necessary to divert portions of the drainage into adjacent sewer systems. For this purpose all existing sewers and inlets were plotted on the portion of the topographic map covering the district under investigation. The district was then subdivided to such an extent that the drainage to each inlet could be determined.

The data were then tabulated in a manner which indicates at a glance at what points the existing sewer is of insufficient capacity, as well as the sizes and grades necessary for the proposed relief sewer. To supplement these studies a house-to-house canvass was then made to determine the extent of the territory affected by defective sewerage as well as to serve as a guide in the recommendation for the proposed relief.

The flooding of cellars by backwater from sewers, and other causes of defective sewerage have been traced to one or more of the following causes:

(1) The improper use of sanitary systems of sewers by the connection of roof leaders and street inlets.

(2) Inadequate provision for storm drainage in sewers intended to receive it.

(3) Defective construction of combined sewers.

The problem of providing relief for such conditions was, therefore, somewhat different from the design of new sewerage, inasmuch as it is obvious that the existing sewers should be used to their fullest extent. In some cases sufficient relief could be obtained by replacing the local sewer with one of larger capacity, in others it was necessary to cut off and divert portions of the drainage into adjacent systems, while in some extreme cases it was found necessary either to reconstruct the sewer throughout its entire length to the outlet, or to provide an addi-

Table II.—Run-Off from Improved Areas in Typical Commercial District.

Area: 30.4 acres.

Character of District: Commercial. Area covered by office buildings, stores and other business houses. No undeveloped area.

Soil: Sand and gravel.

Character of improvement.	Area in sq. ft.	Per cent. of total area.	Estimated degree of imperviousness.	Equivalent impervious area, sq. ft.	Per cent. total area impervious.
Roofs	....	....	...	......	59.8
Public and commercial	881,200	66.5	.90	793,080	....
Interior walks	....	....	...	......	0.8
Brick	7,500	0.6	.40	3,000	....
Cement	10,000	0.7	.75	7,500	....
Street walks	....	....	...	......	8.1
Brick	6,100	0.5	.40	2,440	....
Cement	139,300	10.5	.75	104,475	....
Street pavements	....	....	...	......	16.4
Asphalt, brick, wood block	145,500	11.0	.85	123,675	....
Granite block	111,400	8.4	.75	83,550	....
Macadam and cobble	23,224	1.8	.40	9,290	....
Total	1,324,224	100.0	...	1,127,010	85.1

Impervious coefficient for district, 85.1%.

*These values are adapted from those suggested by Mr. Emil Kuichling in the Kuichling and Bryant "Report on Back Bay (Boston) Sewers."

Table III.—Run-Off from Improved Areas in Typical Tenement District.

Area: 60.0 acres.

Density: 135 persons per acre.

Character of District: Mostly two-story dwellings and stores, with paved interior walks and yards. Essentially a tenement district.

Soil: Clayey sand overlying beds of sand and gravel.

Character of improvement.	Area in sq. ft.	Per cent. of total area.	Estimated degree of imperviousness.	Equivalent impervious area, sq. ft.	Per cent. total area impervious.
Roofs	....	....	...	......	38.2
Residences—Public and commercial	981,200	37.6	.90	883,080	....
Barns and sheds	163,500	6.3	.70	114,450	....
Interior walks	....	....	...	......	6.3
Brick	220,000	8.4	.40	88,000	....
Cement	100,400	3.8	.75	75,300	....
Street walks	....	....	...	......	7.0
Brick	39,500	1.5	.40	15,800	....
Cement	222,600	8.5	.75	166,950	....
Street pavements	....	....	...	......	14.4
Asphalt, brick, wood block	393,900	15.1	.85	334,815	....
Granite block	29,000	1.1	.75	21,750	....
Macadam and cobble	46,800	1.8	.40	18,720	....
Unimproved	....	....	...	......	4.0
Unpaved yards and lawns	415,930	15.9	.25	103,982	....
Total	2,612,830	100.0	...	1,822,847	69.9

Impervious coefficient for district, 69.9%.

tional storm sewer. The latter alternative, however, was rarely possible, as it is generally necessary to place the proposed sewer at the same depth as the existing sewer in order to intercept the tributary or lateral sewers.

Studies for relief sewers were carried to a point where it was possible to recommend the best and most economical methods of relief, as well as to prepare preliminary plans, estimates and reports.

Table IV.—Run-Off from Improved Areas in Typical Combined Tenement and Industrial Districts.

Area: 35.6 acres.
Density: 55 persons per acre.
Character of District: Tenement and industrial.
Soil: Clay and sand to gravel.

Character of improvement.	Area in sq. ft.	Per cent. of total area.	Estimated degree of imperviousness.	Equivalent impervious area, sq. ft.	Per cent. total area impervious.
Roofs	....	....	...	......	24.5
Residences	289,200	18.6	.90	260,280	....
Public and commercial	66,800	4.3	.90	60,120	....
Barns and sheds	79,200	5.1	.75	59,400	....
Interior walks	....	....	...	......	2.0
Brick	35,600	2.3	.40	14,240	....
Cement	22,600	1.5	.75	16,950	....
Street walks	....	....	...	......	5.0
Brick	48,200	3.1	.40	19,280	....
Cement	78,100	5.0	.75	58,575	....
Street pavements	....	....	...	......	6.2
Macadam and cobble	238,600	15.4	.40	95,440	....
Unimproved	....	....	...	......	6.7
Unpaved yards and lawns	692,436	44.7	.15	103,865	....
Total	1,550,736	100.0	...	688,150	44.4

Impervious coefficient for district, 44.4%.

Table V.—Run-Off from Improved Areas in Typical Residential District.

Area: 291.1 acres.
Density: 20 persons per acre.
Character of District: Residential. Well developed. Detached dwellings of two or more stories and in good condition; 2.3 acres open and undeveloped.
Soil: Yellow and blue clay, overlying beds of shale and limestone.

Character of improvement.	Area in sq. ft.	Per cent. of total area.	Estimated degree of imperviousness.	Equivalent impervious area, sq. ft.	Per cent. total area impervious.
Roofs	....	....	...	......	14.4
Residences	1,665,800	13.1	.90	1,499,220	....
Public and commercial	214,000	1.7	.90	192,600	....
Barns and sheds	171,900	1.4	.75	128,925	....
Interior walks	....	....	...	......	2.2
Brick	73,200	0.6	.40	29,280	....
Cement	334,400	2.6	.75	250,800	....
Street walks	....	....	...	......	2.9
Brick	127,000	1.0	.40	50,800	....
Cement	430,600	3.4	.75	322,950	....
Street pavements	....	....	...	......	7.0
Asphalt, brick, wood block	630,200	5.0	.85	535,670	....
Granite block	133,100	1.0	.75	99,825	....
Macadam and cobble	612,300	4.8	.40	244,920	....
Gravel and poor macadam	46,500	0.4	.20	9,300	....
Unimproved	....	....	...	......	9.4
Unpaved yards and lawns	....	....	...	......	....
Tributary to paved gutters	7,246,800	57.1	.15	1,087,020	....
Not tributary to paved gutters	1,000,955	7.9	.10	100,095	....
Total	12,686,755	100.0	...	4,551,405	35.9

Impervious coefficient for district, 35.9%.

Hickory is the strongest Canadian wood. When properly seasoned a hickory column will support a weight of 12 tons per square inch cross-section, which is considerably more than what could be borne by a pillar of cast iron or steel of the same length and weight.

The mineral production of Ontario in 1913 had a total value of $53,207,311, the largest yet recorded in any year. Of this $37,507,935 was of metallic, and $15,699,376 of non-metallic substances. The increase over the output for 1912 was $4,865,699, or more than 10 per cent.

FINISHING TEMPERATURES AND PROPERTIES OF RAILS.

THE U.S. Bureau of Standards has carried on an investigation into the manufacture of steel rails. The main objects of it were to determine, from measurements taken in representative rail mills, the present American practice regarding the temperatures at which rails are rolled; to demonstrate the ease and accuracy with which such temperatures may be measured; to find out what the "shrinkage clause" in rail specifications really means; and finally to determine for rail steels some of the physical properties, particularly those of interest in manufacture and some of which, it would seem, are not sufficiently well known as yet. Among these last are the expansion, melting ranges, critical ranges and temperature distribution throughout a rail section on cooling.

Table 1—Summary of Ingot Temperatures at Blooming Mill.

Mill.	Number of ingots observed.	Average temp. C.	Average time in blooming mill, seconds.	Remarks.
A	20	1140±10	120±25	Excessive time in pits.
	19	1082±16	121±16	In pits 1 hr. 35 min. to 2 hrs.
B	30	1102±12	91±7	Two heats.
C	29	1087±17	71±3	Two heats.
D	43	1118±15	37±2.3	Seven heats.

In the spring of 1913, observations were taken of ingot and finishng temperatures of rails in four representative mills, designated as A, B, C, D. Temperatures were taken with the Holborn-Kurlbaum type of Morse optical pyrometer.

In Table 1 is given a summary of the temperatures of ingots as measured at the blooming mill during rolling for rails, and in Table 2 a summary of finishing temperatures of rails.

Table 3 illustrates with what uniformity of temperature it is possible to carry out the rolling of rails in practice. The letters refer to the position of the rail in the ingot. It is evident that a uniformity of ±10 deg. C. may be maintained.

Table 2—Summary of Rail Finishing Temperatures.

Mill.	A			B	C	D
Location of station	Hot saw			Hot saw.	Cooling bed No. 1.	Just before hot saws.
Distance last pass to station	4			5	3	1
Number of rails	120	70	80	312	171	186
Weight of rails	75	90	100	72	90	100
Type of rail	Bessemer	O. H.	O. H.	O. H.	O. H.	Bessemer and O. H.
Letters indicate location of rails in ingot.	A & D	A & D	A & C	A=957±8	A & D	Mean of
	924±13	976±10	988±23	B=945±9	911±8	A, B, C, D.
	B & E	B & E	B & D	C=935±9	B & E	Bessemer
	918±13	964±12	962±24	D=923±9	901±8	1047±8
	C & F	C & F	....		C & F	Mean of
	906±15	942± 7	....	E=951±8	883±8	A, B, C, D.
				F=937±10	2nd Series	O.H.
				G=920±9	A & B	992±15
				H=903±11	928±6	
				Mean A, B, C, D,	B & E	
				939±9	920±7	
				Mean E, F, G, H,	C & F	
				928±9	904±8	

An inspection of the tables shows that there is practical uniformity among the several mills for the rolling temperatures of ingots for steel rails, the range being from 1,080 deg. C. (1,975 deg. F.) to 1,140 deg. C. (2,085 deg. F.). With the exception of the Bessemer rails of Mill D, rolled at an average temperature of 1,047 deg. C. (1,917 deg. F.), there is no very considerable difference among the finishing temperatures of the rails as observed at the hot saws for the several mills, the range being about 880 deg. C. (1,615 deg. F.) to 990 deg. C. (1,815 deg. F.); or, in other words, the four mills all finished their rails to within 50 deg. C. of 935 deg. C. (1,715 deg. F.) on the average, excepting the Bessemer rails of Mill D. This temperature of 935 deg. C. is 270 deg. C. (520 deg. F.) above the mean value, 665 deg. C. (1,230 deg. F.) of the critical ranges of these rail steels. Concerning the distribution of temperatures within the head of a cooling rail, it is shown that the centre of the head is some 50 deg. C. (120 deg. F.) to 60 deg. C. hotter than the optical pyrometer reading at 935 deg. C.; therefore the centre of the head is finished, on the average, at about 325 deg. C. (615 deg. F.) above the critical range for 100-lb. sections.

The tables of finishing temperatures show several other facts of interest. For example, it is evident that it is a possible and easy operation to determine accurately the temperature of each rail length in succession as it arrives at the hot saw. (See Table 3.) From the measurements at Mill A, the relative temperatures of rails differing in weight of section, rolled from ingots having closely the same weights and temperatures, are shown. Thus the average of the finishing temperatures of the top rails (A and D or A and C) for 100, 90 and 75 lb. sections were, respectively, 988 deg., 976 deg. and 924 deg., and similarly for the others.

Chemical analyses and microphotographic examinations were also made and the mechanical properties determined for a number of samples of rail the rolling of which had been observed. From a comparison of these few observations, there appears to be not a sufficient degree of correlation to warrant associating very specifically any of the characteristics defined by these three methods of examination, either with the temperatures of rolling here observed or with each other.

The following thermal properties of these rail steels were determined in the laboratory: The critical range on heating is located (maximum) to within 7 deg. C. of 732 deg. C. (1,350 deg. F.) for the ten samples of O. H. and Bessemer steels examined. On cooling, the critical range lies between the limits 680 deg. C. (1,256 deg. F.) and 650 deg. C. (1,202 deg. F.). The melting or freezing range for rail steel extends from about 1,470 deg. C. (2,680 deg. F.) to nearly the melting point of iron located at 1,530 deg. C. (2,786 deg. F.).

The expansion for O. H. and Bessemer steels is not the same. Above 800 deg. C. (1,470 deg. F.) the expansion for both increases linearly with temperature and the linear coefficient per degree Centigrade has the following mean values from 0 deg. to 1,000 deg. C.; (1) For Bessemer steel (carbon .40 to .50 per cent.) = 0.0000146, (2) for open hearth steel (carbon .65 to .70 per cent.) = 0.0000156.

The average composition of the Bessemer steel was carbon = 0.40 to 0.50 and manganese = 0.76 to 0.93; of the open hearth steel, carbon = 0.66 to 0.70 and manganese = 0.66 to 0.72.

In 1909 the American Society for testing Materials limited the shrinkage allowance on 100 lb. sections to 6¾ in. in 33 ft., or to an equivalent of 1,947 deg. F. (1,064 deg. C.) for O.H. and 2,055 deg. F. (1,124 deg. C.) for Bessemer rails. This specification is still in force.

Table 3—Measurement of Temperatures of Head of Rail at Hot Saws for 72 Lb. Rails.

A	B	C	D	Mean ABCD	E	F	G	H	Mean EFGH
954	942	942	926	941	954	943	926	896	930
966	953	948	928	943	965	945	919	898	932
956	955	943	917	943	954	931	919	902	927
958	945	926	929	939	952	944	920	906	923
966	960	943	932	950	960	...	922	905	929
968	945	940	929	945	954	940	920	901	929
943	931	918	914	927	...	...	...	...	...
...	...	...	...	...	948	933	918	908	919
958	951	937	929	944	948	929	918	894	922
962	923	920	917	928	940	920	908	894	915
942	934	922	908	912	940	920	902	878	904
922	912	908	887	907	926	906	894	872	902
922	909	899	897	907	912	897	882	866	889
926	917	905	897	912	926	903	902	882	904
				NEW HEAT					
953	947	935	920	938	932	931	913	903	920
966	954	932	912	939	954	937	929	...	940
954	945	934	922	938	954	945	922	914	934
956	957	936	919	941	960	952	935	918	941
964	949	934	926	943	954	943	...	913	936
963	957	945	934	951	949	929	915	...	930
952	943	937	930	940	950	943	924	920	934
962	958	940	936	951	957	940	934	910	935
966	957	940	932	949	951	934	918	897	924
954	943	935	926	939	938	937	918	896	922
956	943	929	922	936	955	943	922	901	930
968	954	943	931	947	958	943	924	916	935
964	946	943	935	946	964	952	932	913	942
958	943	943	931	944	965	946	931	920	940
960	946	944	931	945	946	943	926	918	934
961	954	946	930	947	954	943	935	918	938
958	949	945	943	949	957	935	931	920	936
955	947	939	929	943	945	942	932	908	931
965	953	939	939	949	968	953	941	917	945
963	942	932	919	939	958	936	919	907	930
962	951	937	919	943	957	940	912	896	927
943	937	922	914	929	945	922	908	901	920
960	944	943	929	944	966	957	932	906	940
969	954	946	931	950	964	9,4	928	912	936
975	962	953	934	957	954	952	920	908	934
957	939	928	908	933	946	931	916	888	921
*957±	945±9	935±9	923±9	939±9	951±8	937±10	920±9	903±11	928±9

* This line represents the mean degree of temperature of above table.

A rail of 100 lb. section in cooling freely in air from a uniform temperature of 1,070 deg. C. (1,960 deg. F.) reaches its recalescence point at 670 deg. C. (1,238 deg. F.) in about 8 min. 30 sec. The maximum difference in temperature between the centre and outside of the head during this cooling is about 85 deg. C. at 1,000 deg. C. (1,832 deg. F.), drops to 55 deg. at 900 deg. C. and to 30 deg. at 800 deg. C., becoming 0 deg. again at 670 deg. C.

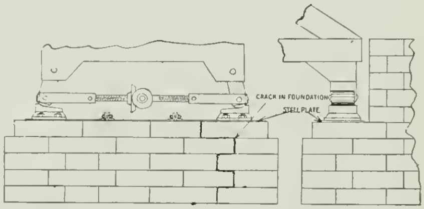
A comparison of the shrinkage clause in American rail specifications (for example, those of the A.S.T.M.) with the expansion of rail steel shows that this clause permits finishing rails at 1,120 deg. C. (2,045 deg. F.), or 450 deg. C. (840 deg. F.) above the critical range of rail steel, and above the temperature at which many ingots for rails are actually rolled in practice and well above the practice of the rail mills for finishing temperatures, as shown in Table 2. Such a shrinkage clause, therefore, does not serve the avowed purpose of limiting the finishing temperatures to a value slightly above the critical range.

In conclusion, it should be emphasized that the various series of observations recorded in this investigation are of but a preliminary nature and do not pretend to solve the question of the relations between temperature of rolling and the properties of rails. It would seem desirable to make a much more complete and comprehensive study of the various matters mentioned and of related questions than has hitherto been attempted, and on a scale commensurate with the importance to the community of the problem of sound rails.

BRIDGE REPAIR ON C.P.R.

By J. G. Koppel,
Electrical Superintendent of Bridges, Sault Ste. Marie, Ontario, Canada.

On the end piece of a swing bridge crossing the Ste. Marie Ship Canal at Soo, Ontario, a repair was recently made in a very efficient manner. The bridge is 407 feet in length, over which runs a single track for the Canadian Pacific railroad trains. The swinging and the end piece shoe-jacks operate by electric motors from a centre cabin elevated over the track. From time to time it was found that the bridge tended to tilt to one side, especially the south end, which is on a curve,



BRIDGE REPAIR ON THE CANADIAN PACIFIC.

and finally a serious crack developed in the masonry which grew worse every day, and in order to keep the bridge safe we had to devise some kind of relief or safeguard to prevent a total rupture.

Arrangements had to be made to make the necessary repairs without interrupting the running of the trains on the track, and at the same time not to interfere with boats passing through the canal. The accompanying drawing shows the crack in the masonry which amounted to fifteen-sixteenths of an inch, and also shows how the repairs were accomplished. A one-half inch steel plate was made in three sections, and drilled to fit on the jack-shoe bolts, and one jack-shoe at a time was removed and the plate laid in place and the jack-shoe replaced. When both plates were secured in position, then the centre plate was put in and the bolts screwed down, and when all were in tension the masonry was drawn into its original position, while a mixture of cement was poured into the crack, which made a very good job, as the foundation is now apparently as good as could be desired, and safer than the original structure, as nothing short of an earthquake could move the steel plate that we added to the structure.

Not only so, but it is evident at a glance that a new idea has been added to structures of this particular kind. Masonry under direct vertical pressure is always reliable, but under slightly horizontal pressure of an intermittent kind, such as is caused by the oscillation of a heavy locomotive and attached train rounding a curve the tendency of the masonry to crack or dislocate is very great, and a reinforcing plate should be used.

POSSIBLE FAULTS IN OUR METHODS OF TEACHING.

By I. F. Morrison,
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It is the chief function of any engineer, young or old, to solve problems, and to obtain, not only a solution, but the best solution considered from all points of view. Such a best solution requires a sound knowledge of the fundamental principles of the physical, chemical and mathematical sciences and some understanding of business methods, economics, law and many other important fields. At present it is not possible to deal with these latter requirements as extensively as seems desirable in our engineering courses within the limited amount of time allowed. The young engineer must pick these up for himself; and there is no reason why he should not do so if he has had the proper training in other fields and has learned to study effectively. The fundamental principles and their application to problems, coupled with a training in actual methods of study, seem to be the important qualities to be desired in an engineering graduate.

One of the outstanding faults of the present-day engineering student is his dependence on problems and on text-books. Such dependence is a habit due to poor training, which in turn is fostered by the improper use of text-books and the assignment of poorly chosen problems. The first is due to the habits acquired by the student during an early part of his school training; while the latter is wholly due to the teacher in his engineering courses. Without doubt, problem-work is highly desirable. It is an efficient, practical method of applying practice in the use of fundamentals. The tendency, however, is to bury the fundamentals in problems with the resulting loss of independence on the part of the student. The childhood propensity to imitate and to follow seems to persist in the minds of many engineering students even until the time of graduation. Problem-work should retard rather than promote such a growing dependence and can be used effectively in overcoming the difficulty.

No doubt the modern methods of our public school education systems are in part responsible for this condition; and for that reason alone, an inimical influence should be brought to bear upon the student by the engineering college tending towards independency of thought and ability. For this, quality and not quantity in most cases should be required in problem-work. Drill is for those who are followers, not for leaders. The engineering college should aim to effect the transition of its newly accepted students from dependent to independent thinkers, from followers to leaders with intuition and initiative.

A problem which requires an indirect solution is of greater value than several which may be quickly solved by a formula. The following problem is taken from one of the most recent text-books on applied mechanics, and is preceded in that book by an illustrative problem in which the statement is made "Apply the formula," referring to the well-known formula $F = Ma$. A force of four pounds causes a certain mass to move from rest through 18 feet in 3 seconds. Find the mass. According to the worked example which precedes it, the student applies the formula; which is a very common type and is applied in quantity. Eventually the student learns, not that the force produces an acceleration inversely proportional to the mass or an equivalent fact, but that simply $F = Ma$.

Consider the other type of problem which demands something more than a mechanical application. An iron ball, starting from rest, rolls down an inclined plane 10.2 feet long in 4.8 seconds. What is the inclination of the plane with the vertical? The solution is indirect and requires a careful consideration of the forces which act to cause the ball to roll down the plane.

The first problem, while not quite direct, demands but little reasoning. At this point the student has already learned the formula $s = \frac{1}{2}at^2$, and is now also dependent on the fact that $F = Ma$ is the ultimate solution of his problem. Such an exercise is nearly worthless, unless the student needs practice in multiplication. Many problems of this sort will make the student dependent on a formula for the solution of any problem so that ultimately his ability to solve problems will be limited to doing those which he has seen done elsewhere, or for which he can find similar cases already worked in his text-book.

To be of the greatest value, problems should demand the applications of principles and common sense rather than formulæ. They should be interesting and practical. The ability to understand new problems and to obtain the best solution for each is the ultimate aim. This can be accomplished only by independency in thought and ability.

Objections have been raised to the present method of usage of symbolic formulæ. Everyone seems to agree that such formulæ should be thought of in terms of English words and that they should be so taught; but few seem to realize that the problem-work is perhaps partly responsible for the objectionable conditions. Most students naturally follow the line of least resistance where it is made evident. "Apply the formula." A short symbolic formula is not only attractive from this point of view but is soon recognized as an easy means to an end. Problems which give merely a drill in the use of symbolic formulæ and therefore require only a mechanical operation, might well be avoided. The benefits derived from them cannot be greater than the effort applied to them

Symbolic formulæ have their place: their role is important, but their importance is secondary. We should hardly think of teaching shorthand to children who have not yet learned to read and write in the ordinary way. Much less would we think of mixing reading, writing and shorthand together, when taught. Then, why should we seek to start a subject in elementary mechanics with notations immediately followed with formulæ? Perhaps it would be well to avoid formulæ entirely for a while and to allow the use of them to be developed naturally by the student. It would be interesting to watch the development of symbols and formulæ in an elementary class. The writer believes that each student would eventually evolve some system of notation and make up his own symbolic formulæ. This would be putting the formulæ in their proper relation to the subject: it would give the proper weight to their importance.

However, the ability to translate a derived formula is of great importance. This point must not be overlooked; and the translation of formulæ which have been derived should be insisted upon. Students will see the value of writing the statement of some physical law with single letters more readily than they will observe the complete meaning of a derived formula. Nevertheless, if they have been the promoters of their own formulæ originally, this difficulty should not persist.

Efficiency, like economy, is sometimes false. Both must be developed along natural lines. It is not economy to set an unskilled workman to work with a valuable machine; nor is it efficiency to require an untrained student to use a symbolic formula. After all, formulæ are merely the result of a natural method developed to obtain efficacy.

STEEL TOWER TRANSMISSION LINES

A STUDY ON THE LOCATION AND CONSTRUCTION OF HYDRO-ELECTRIC POWER TRANSMISSION LINES AND DISCUSSION OF PRESENT EXPERIMENTS BEING CONDUCTED RELATIVE TO THEIR OPERATION.

By ALBERT B. CUDEBEC,

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At first glance it might seem that transmission line location and construction falls within the field of the electrical engineer. However, it is likely that the civil engineer is a more successful locator and construction man, while a combination of electrical and civil engineering experience are the ideal requirements for a new and growing branch, soon to become known as "Transmission Engineering."

Hydro-electric power development may be classified into three operations: Generation, Transmission and Distribution.

Of the three divisions, transmission is the weakest link, and is receiving an unusual amount of study and experiment at this time.

Large water-powers are frequently located in isolated districts many miles from the power market. Scarcely two decades past, many large water-powers were not available for commercial purposes, chiefly because this art of transmission was as yet not sufficiently perfected.

Transformers were in their embryo stage and direct current almost universally used.

With the coming of modern transformers and alternating current, most water-powers were brought within commercial operating distances of a possible market.

Electrical designers have been successful in the development of reliable generators and transformers, while the solving of low-tension distribution problems has kept the pace, but the transmission link still gives cause for grave concern.

Continuity of power is absolutely essential to obtain and hold the business and good-will of the consumer, and severe penalty clauses in power contracts for interruption are the rule rather than exception.

Only a few years ago voltages of 11,000 were the average, while the more daring engineers were attempting transmission at 44,000 volts. To-day many systems are operating at pressures between 130,000 and 150,000 volts.

The location and construction of lines carrying these lower voltages were comparatively simple matters. The distances covered were short, and conductors, insulators and poles were cheap in comparison with the modern high-voltage steel tower construction.

Franchises along public highways were easily obtained, and when found advisable to cross privately owned property, the right to set a few poles could be secured at a nominal cost. The securing of a profile was needless, and the construction foreman usually chose the pole locations by inspection, while little or no attention was paid to elimination of angles.

With the rapid advance in the art of transmission, the steel tower has displaced the wood pole for high voltages. One good example of this quick change occurred under the writer's observation. An expensive wood pole line carrying a single 60,000-volt circuit, which was completed for service a little over four years ago, was pulled down during the past summer season and replaced with a double-circuit 110,000-volt steel tower line. The rule is, however, to retain the old lines and, if desirable, parallel them with a new line, the old one being kept for emergencies in case of break in the new line.

Lines carrying moderate loads, together with line pressures limited to 60,000 volts, are still supported upon poles. Pin-type insulators are still used, but the suspension insulator is very rapidly displacing the old type, even at these moderate voltages.

Steel tower lines are of two distinct types:—

(1) The rigid towers, capable of resisting horizontal stresses in all directions.

(2) The flexible type, whose function is to support the conductor only and will not resist horizontal stresses parallel to the direction of the line.

If a flexible type is used, it is necessary to specify that a rigid tower be placed about every mile to take the strains in conductor after sagging.

As the flexible tower is not commonly used, we will refer only to the rigid or square-base tower hereafter.

A modern tower line, carrying current at pressures between 130,000 and 150,000 volts, will cost from $10,000 to $14,000 per mile, and its location demands as careful study as the location of a railroad. It is an old adage that successful railroad locators are born and not made, and it seems probable that this term will soon apply to transmission locators. The characteristics necessary for a successful locator are: (1) A thorough knowledge of the factors which affect the first cost as well as subsequent operation. (2) A keen sense of observation so that physical facts are quickly noted and all advantages taken.

The essential difference between railroad and transmission line location is the elimination of a necessary limiting grade. Public highways, villages and telephone lines are to be avoided, but primarily a minimum distance between terminals is the goal sought by all locators.

A minimum number of angles is also desired, as every angle means a heavier tower with a "dead-end" and "strain-point," which are expensive.

When the pressure on an overhead transmission system exceeds a certain critical value, depending upon the spacing, diameter and elevation of the wires, there will appear on the surface of the conductors a halo-like glow, to which the name of "corona" has been given. Apart from its luminous effect, the appearance of the corona is accompanied by a certain loss of power, which becomes serious very quickly after the critical point is passed. If the electrical designer has specified wire and spacing which is near the corona limit at the average elevation of the line the loss rapidly increases with the elevation and is proportional to the length of the line passing over the high elevations.

* The Cornell Civil Engineer.

There are other phenomena due to corona which are purely electrical, which are of no interest to the locator, but lie within the sphere of the electrical designer.

The effect of altitude being so important, transmission lines which pass over mountain ranges must be kept in as low passes as possible, but if high points are unavoidable, the length of line over these points should be kept a minimum.

Tower lines are cheaper if located across rolling hills and valleys, where longer spans and fewer towers per mile are obtainable than in level country.

Where reliable U.S.G.S. sheets are not available, it is preferable to first run a preliminary line, then project the location. When the located line is being staked out, a careful classification of the ground crossed should be taken. This should include swamps, rock out-crops, class of timber, cultivated ground, etc.

At the same time a line of accurate levels should be run which will show, along the centre line, all breaks in ground of a foot or more. All transverse slopes of more than 10° should be recorded.

As soon as the detailed profile has been completed, tower locations can be made in the office. The method of locating towers which has proven to be the most practical is the one described in the "Electrical World" under date of September 11th, 1911, by Mr. J. M. Viehe.

On all high-voltage lines which are supported by suspension type insulators, it is necessary to carefully compute the relation between length of span and corresponding sag between the range of temperature which may be expected to occur in the district through which the line is passing.

During extremely cold weather, an uplift upon a suspension insulator will cut down the clearance between conductor and the towers which might cause "flashovers," and if the uplift is serious, would cause mechanical failure of the crossarm.

All towers of the rigid type are ordinarily designed to withstand great strain in a horizontal direction, but are not supposed to resist any great amount of upward pull. It is, therefore, necessary to place the towers in such a position that no great upward pull will be exerted.

The office procedure for properly locating towers is first to make certain assumptions for loading, i.e., assume a maximum wind pressure added to the weight of the conductor itself; then to the sum of these two must be added the weight of an arbitrary thickness of sleet which may be expected to accumulate upon the conductor at times. Several conditions are investigated for sag and tension, as sleet and ice, with a sudden drop in temperature, or a combination of any of these assumptions.

Assuming that the copper conductor will take the form of a catenary between supports, the sag for any length of span can be readily computed. A certain minimum clearance from the ground is specified, depending upon the character of country through which the line is passing. A templet representing conditions at maximum temperature is then prepared, using the same scale as the plotted profile.

After the adjacent tower locations have been made, it is necessary to test these locations for cold weather conditions. This test is applied by the use of a similar templet, which is drawn to scale, and shows the position of conductors as they will exist at minimum temperatures If the contraction of the copper is sufficient to lift the conductor above the intervening tower, it will be necessary to change the length of span on either side until a position is found where no uplift to insulators will occur and at the same time keep within the minimum prescribed clearance during maximum temperatures.

A great number of combinations will occur while studying the proper location for transmission line towers, and the most economical points for locations are often the result of several days' study.

Owing to the fact that interruption to service are not unusual from line troubles, it is best to build duplicate lines if feasible to finance the construction. If a duplicate line is authorized, it is better to construct it upon separate supports located over a different route in order to avoid the chance of destructive storms putting both lines out of commission at the same time. Separate routes for transmission lines, will, of course, increase the cost of patrolling and right-of-way, which is in turn offset by more continuous service.

All terminals of a modern power distribution system must be kept in constant telephone communication. In fact, the telephone is as necessary to the modern power system as is the telegraph and block signal to the operation of a modern railroad. Statistics show that interruptions and troubles with the average operating telephone system are more frequent and cause more worry to the operating superintendent than does the main transmission line. It frequently happens that when a break in the transmission line occurs, the telephone line will also be out of commission. This is more likely to occur if the telephone line is strung upon the same supports as the main conductor. It is, therefore, advisable to build a separate telephone line of modern construction at a sufficient distance from the transmission line to avoid the chance of crossing with the main conductors.

Five years ago transmission line towers were averaging from 2,000 to 3,000 lbs. each, while to-day towers of 5,000, 7,000 and 12,000 lbs. in weight are not infrequent. The average heavy tower when erected will cost from $700 to $1,000, and it is, therefore, good business to study the line very carefully, indeed, before finally specifying locations.

As soon as all tower locations have been made, a field party should stake these towers out upon the ground, and this is where the best of judgment must be exercised. It is frequently found that the locations as selected in the office will place the tower directly upon a pile of rocks, or in wet ground, etc. By moving the tower a short distance in either direction, these natural difficulties may be avoided. At the same time, it must be borne in mind that a slight change in tower locations will very materially alter the position of the conductors with reference to the ground, as the amount of sag changes rapidly with changes in span length. The field man must, therefore, be thoroughly acquainted with the technical detail of the scheme by which towers are located, and must be equipped with a celluloid templet in the field and adjust the small changes in location so that all requirements are fulfilled.

If there are several different types of towers, which may be used, such as different heights, weights and side-hill extensions, etc., it is possible for the field men to change the office selection of a tower with a 10 or 20 ft extension to one with a 4 ft., 6 ft. or 8 ft. side-hill extension, thereby saving expensive excavation and at the same time reducing the amount of steel.

The location of all towers having been made, the line is now ready for construction. The procedure of construction is as follows:—

(1) Clearing line of all timber, including "Danger" timber outside of the right-of-way proper. (2) Excavation for footings. (3) Distribution of stubs and tower steel. (4) Placing of stubs in concrete or earth and backfilling

same. (5) Assembling towers, including hanging of insulators or crossarms and distribution of small hardware for stringing purposes. (6) Erection of towers. (7) Stringing of conductor. (8) Cleaning-up crew.

In order that the construction men may be supplied with the best information possible, it has been found economical to condense all the information regarding location, types of towers, numbers of insulators, etc., into a pamphlet, which is furnished to each general foreman. It is also found of great assistance to the man in charge of material distribution, to be furnished with a sheet showing the railroad stations from which material must be hauled, and which will include the number and types of towers shipped to each station.

Whenever the supporting ground is poor or ground water is known to stay continuously in the holes which are excavated for stubs, it is always good policy to concrete the stubs and protect the channels which connect to the towers with a concrete collar, but if the ground is good, firm, dry earth, concreting is not necessary except for angle and dead-end towers. If the line to be constructed specifies towers which range from 3,000 to 3,500 lbs. it is cheaper to leave the holes open and bolt the stubs to the towers after erection, no templet being necessary to hold the stubs in place. On the other hand, with heavy towers, ranging from 5,000 to 12,000 lbs. and upward, it is better to set and backfill all stubs previous to the erection of towers by means of a steel or wood templet.

Common labor is all that is necessary for the entire construction program, including stringing of conductor, but it has been noted that within the last ten years labor unions have been insisting that union steel workers shall be specified for assembling and erection, and that union linemen must be used for stringing conductor. This is entirely unnecessary as far as results of the work are concerned, as it only takes a few weeks to train men to assemble and erect towers, and string conductor. In fact, it has been found that skilled steel workers and linemen have to be trained to this class of work in the same manner as common labor.

There are several methods of erection of towers, but the writer prefers the "A" frame method. A crew of 8 men will assemble on the average of from 2 to 3 towers per day and a crew of 15 men will erect from 8 to 16 towers daily if the ground is not too rough.

The conductor used upon modern heavy transmission lines will run from 150,000 to 300,000 c.m.; 250,000 c.m. conductor weighs about ¾ lb. per lineal foot. The tackle and grips necessary to pull this conductor must be unusually heavy. The conductor comes from the manufacturer in ½ mile or mile reels, weighing from 4,000 to 6,000 lbs each, and these reels are usually mounted upon some simple standard. An eccentric reel has been found very convenient. The conductor is pulled out by teams and passed through especially designed wooden snatch-blocks, the sheave for which is preferably lignum vitae.

The splice between two pieces of heavy conductor must be very carefully made. Copper splicing sleeves are now universally used with which to twist them into position.

It is very necessary to protect hard-drawn copper from being injured at the surface, and every precaution is taken to keep the conductor from being scored by rocks or being struck by any object which will crack the surface. The conductor is usually sagged and tied in at every mile. The pull necessary to properly sag the conductor depends upon the temperature. This stress is measured by the use of a dynamometer, but it is preferable to check the sag by sighting from one tower to the next to avoid trouble in case the dynamometer should get out of repair.

An average crew of 12 men will string from one to two miles of conductor per day, consisting of 6 copper wires and 2⅜ inch steel ground wires. The entire organization necessary to construct a line 135 miles long of 250,000 c.m. conductor during a period of seven months, is approximately as follows:—

1—Superintendent	2—Clerks
1—Assistant Superintendent	2—Stenographer
2—General Foreman	1—Head Timekeeper
1—Cost Clerk	8—Assistant Timekeepers
1—Cashier	1—Chief Material Man

2—Clearing Crews,	1—Foreman and	20 men (each crew)
2—Hole Digging Crews	1 " "	40 men " "
2—Distributing tower steel, concrete, material, conductor, etc.	1 " "	4 helpers and 50 teams (each)
3—Concrete Crews,	1 " "	20 men (each)
3—Assembling Crews,	1 " "	4 straw bosses and 40 men (each)
3—Tower Erection Crews,	1 " "	18 men and 2 teams (each)
2—Wire Stringing Crews,	1 " "	50 men and 8 teams (each)
2—Clean-up Crews	1 " "	20 men (each)

Commissary and Quartermaster Equipment.

8—Camps each equipped with an average of 20 tents each.
1—Cook
2—Flunkies
1—Commissary Clerk
NOTE: All crews are not working at one time
TOTAL AVERAGE FORCE—600 Men
100 Teams

The advance in the art of transmission has been great in the last ten years, and as yet no stable conditions seem to have arrived. It, therefore, seems doubtful to the writer that it is advisable at this time to spend so much capital in constructing heavy steel tower lines which may be obsolete within six or eight years. The life of modern towers, if properly erected and inspected, will average from 30 to 50 years. We believe that until the present rapid advance in the art of transmission has more nearly reached a standard, it would be better to construct with the idea in view of re-building in ten years. On the contrary, it is claimed that the investing public would not be interested in financing temporary construction, but will cheerfully invest in projects calling for permanent construction.

The length of span between towers is usually not limited by the strength of the conductor itself, but rather by the horizontal spacing necessary to avoid crossing due to side-swaying. Whenever spans of unusual length are necessary, copper-clad steel conductor is specified This has practically all of the strength of a high-grade steel cable, coupled with the conductivity of copper. By pulling this conductor to a much higher tension than ordinary hard-drawn copper, sufficient horizontal clearance between conductors can be secured and still retain towers using standard clearance.

During the past year or so, some transmission engineers are attacking the policy of increasing the weights of towers and extending the lengths of spans, claiming this policy to be false economy. At a recent convention of the American Institute of Electrical Engineers, held at Vancouver, B.C., a very spirited discussion took place over the question as to whether it would not be better to reduce the length of spans rather than increase them.

The Provincial Government of British Columbia is erecting two new pumping stations on the dyked lands and adjoining the Pitt River. One of these stations is to be located on the Maple Ridge side and the other on the lower Coquitlam side of the river. These new plants have been necessitated by the growing utilization of these dyke lands. In the last two years a number of industries have been located on the Coquitlam side, and these required considerable land drainage pumping during the summer freshet season.

SURGE TANK PROBLEMS V.

CONTINUATION OF ANALYSIS OF SPILLWAY EFFECT — STUDY OF SURGE TANK WITH VARIABLE CROSS-SECTION — APPROXIMATE FORMULA FOR SURGE TANKS WITH CONSTANT CROSS-SECTION.

By PROF. FRANZ PRASIL.

Authorized Translation by E. R. Weinmann and D. R. Cooper, Hydraulic Engineers, New York City.

Investigation of the Influence of $h = u.v^2$.

Finally, a study may be added which permits a comparison between the results of the assumption already made (that $h = n.v$), and the results obtained if we use the usual formula $h = u.v^2 = u^1.\frac{Lv^2}{P.2g}$ where the friction coefficient u^1 is again assumed as constant (P = hydraulic radius of the conduit). With this condition it is necessary to use the first original equation (15) in which we must, according to the direction of the flow in the conduit, be careful to use the right sign for h. If this makes the investigation somewhat complicated, it may be said that the differential equation, which we obtain introducing the value of v in the continuity equation (17) is not only of the second (i.e., higher) order, but also of the second degree, so that difficulties occur in the determination of the general integral. This is especially the case if in the equation mentioned $q > o$ and variable.

Therefore, in the following we consider only for comparative purposes the case of a sudden shut-down of Q and for the phase of the first surge. In order to get more generality, we first consider the surge tank section as variable with the height, which means that it is assumed as a given function of z. The motion equation is then:

$$\frac{L\,dv}{g\,dt} + z + h = o. \qquad - \quad - \qquad (15\text{ A}).$$

The equation of continuity is:

$$a.v = A.s \qquad - \quad - \quad - \qquad (17\text{ B})$$

If we multiply equation 15 A with $a.v.dt$, it follows, considering equation (17 B)

$$\frac{L.a}{g}\,v.dv + zA\,s\,dt + h.A.s.dt = o \qquad (90)$$

$A.s\,dt = A.dz = dV$ represents the change of the water volume V in the time dt. It also represents, with given surge tank dimensions as function of z or with reference to the graphical demonstration appearing further on, the function of a variable x where $z = x - h_1$ and where V is measured positive up from that level which lies below $n - n$. That is, for $z = -h_1$ or $x = o$; $V = o$.

With $h = \frac{u^1\,L\,v^2}{P.2g}$ and $h_1 = \frac{u^1\,L\,v_2^2}{P.2g}$ and multiplying (90) with $\frac{2g}{La}$ we get

$$d(v)^2 + [\frac{2g}{L.a}\,.\,x + \frac{u^1}{P.a}(v^2 - v_2^2)]\,dV = o$$

If we say $v^2 = y$ $\quad v_2^2 = y_2$ $\quad \frac{2g}{L.a} = a_1\ \frac{u^1}{P.a} = \frac{1}{a_2}$ the total differential equation follows:

$dy + [a_1 x + \frac{1}{a_2}(y - y_2)]\,dV = o$ which integration can be done introducing the integrating factor $\mu = e^{\frac{V}{a_2}}$

$$y - y_2 = -a_1 e^{-\frac{V}{a_2}} \int_0^V x\,e^{\frac{V}{a_2}}\,dV$$ and introducing the values for y, a_1, a_2.

$$v^2 = v_2^2 - \frac{2g}{L.a}\,e^{-\frac{u^1V}{P.a}} \int_0^V x\,e^{+\frac{u^1V}{P.a}}\,.\,dV \qquad (91)$$

With help of this equation v may be found as a function of V and x, because by given relation of the volume V to x and vice versâ, in formula (91) $\int_0^V x\,e^{+\frac{u^1V}{P.a}}.dV$ may be determined by means of quadrature even if $V = F(x)$ is given only by a curve. The method is illustrated by the diagram shown in Fig. 12. The relation of the volume V to x is shown by a curve, the abscissæ of which represent the values of V and the ordinates the values of x. The construction of the x curve $I - I$ may be accomplished, based on the given dimensions of the surge tank. $V = o$ corresponds, as said before, to the operating level for a flow of Q_1 cubic feet per second. With the same abscissæ, we construct a curve II — II, the ordinates of which are given by the values $e^{+\frac{u^1V}{P.a}}$ and another curve III — III with the ordinates $x.e^{\frac{u^1V}{P.a}}$ and then the integral curve IV — IV. If we construct a further curve V — V, the ordinates of which we get if we multiply the ordinate values of the integral curve by $\frac{2g}{L.a}\,e^{\frac{u^1V}{P.a}}$ and if we construct at the distance (v_2^2) a

line parallel to the axis of abscissæ we then see that the difference of the ordinates between the (v_2^2) line and the curve V — V gives the values of v^2. Naturally, we must select suitable scales for all curves, that is to say, for their ordinates. The scale for the last curve is naturally the same as for (v_2^2). The intersection of the last curve with the parallel (v_2^2) determines the ordinate which gives the value of V on the axis of abscissæ, for which $v = o$, that is, when the highest water elevation occurs. The corresponding ordinate of the x curve gives the height of the highest elevation above the operating level.

If A is constant: $V = A.x$ and equation 91 becomes

$$v^2 = v_2^2 - \frac{2\,g.A}{L.a} . e^{-u^1 \frac{A.x}{P.a}} \int_0^x x\, e^{u^1 \frac{A\,x}{P.a}} dx$$

If we introduce $\frac{2\,g}{L} . \frac{A}{a} = \frac{1}{B^2}$; $u^1 \frac{A}{P.a} = \frac{1}{D}$ we get

$$v^2 = v_2^2 - \frac{e^{-\frac{x}{D}}}{B^2} \int_0^x x\, e^{\frac{x}{D}} .dx$$

$$v^2 = v_2^2 + \frac{D^2}{B^2} \left(1 - \frac{x}{D} - e^{-\frac{x}{D}}\right) \qquad (92)$$

And for the computation of the maximum value X of x ($v = o$)

$$\frac{v_2^2 . B^2}{D^2} + 1 = \frac{X}{D} + e^{-\frac{X}{D}} \qquad (93)$$

The results here obtained may now be used for comparative purposes with the results of the example of case (A).

$v_2 = 6.63$ feet per sec. $\qquad \frac{v_2^2}{2\,g} = .68$ feet

$h_1 = 9.6 \text{ feet} = \frac{u^1}{P} . 9050.0.68$

$\frac{u^1}{P} = \frac{1}{641} \qquad \frac{1}{D} = \frac{u^1}{P} . \frac{A}{a} = \frac{1}{9.6}$

$\frac{1}{B^2} = \frac{2\,g\,A}{L.a} = \frac{1}{2.094} \qquad B = 1.447$ sec.

$$\frac{v_2^2\, B^2}{D^2} + 1 = \left(\frac{6.63^2 \times 1.447^2}{9.6^2}\right) + 1 = 2.00$$

Therefore

$$\frac{X}{D} + e^{-\frac{X}{D}} = 2.00$$

$$\frac{X}{D} = 1.86 \qquad X = 17.81 \text{ feet}$$

In case (A), where we assume the same conditions with $h_1 = n.v$ in which $n = 1.445$ seconds, we got z max $= 6.55'$ and therefore the highest elevation above the initial level z max $+ h_1 = 6.55 + 9.6 = 16.15'$. This

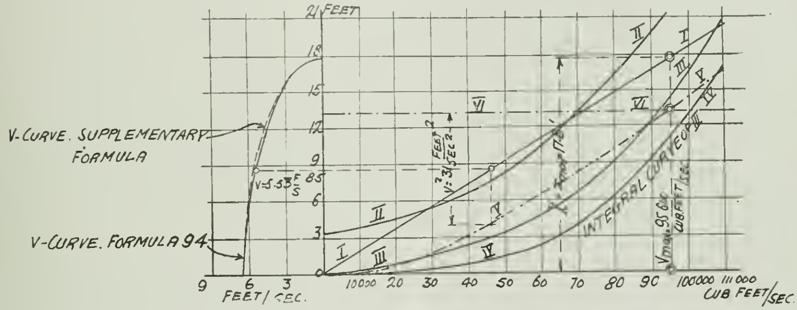

Fig. 12.

value is smaller than the value which we computed for X by 1.66 feet, and it is necessary for us to correct the formulæ obtained under the assumption that $h = n.v$, in order to get as near as possible to the new results. For this purpose, we assume that for the expression of the elevation x above the initial level the formula

$$\left.\begin{aligned} x &= h_1 + z = h_1 + R.e^{-\frac{t}{2\,T_0}} \sin\left(\beta + \frac{t}{T_1}\right) \\ \frac{dx}{dt} &= s = \frac{R}{T}.e^{-\frac{t}{2\,T_0}} \sin\left(2\gamma - \beta - \frac{t}{T_1}\right) \end{aligned}\right\} \qquad (94)$$

with $tg\,\gamma = \frac{2\,T_0}{T_1}$ and $\frac{1}{T^2} = \frac{1}{T_1^2} + \frac{1}{(2\,T_0)^2}$

and therefore

$$\frac{d^2x}{dt^2} = -\frac{R}{T^2}\, e^{-\frac{t}{2\,T_0}} \sin\left(2\gamma - \beta - \frac{t}{T_1}\right) \qquad (95)$$

should be used, where the values R and β are again to be determined from the initial conditions, that is to say, where $t = o$, $x = o$ and $z = h_1$, $\frac{dx}{dt} = c_1$, but the values

T_0 and T and T_1 must be determined, not as before from the given dimension, but from the condition that X becomes the maximum value of the elevation above the initial elevation, that is, for $x = X$ the derivative $\frac{dx}{dt}$ must become zero, and as before for $x = o$, the second derivative $\frac{d^2x}{dt^2}$ becomes zero. From the latter condition follows:

$2\gamma - \beta = 180^\circ = \pi$ therefore $\gamma - \beta = 180 - \gamma$

$\beta = 2\gamma - 180^\circ$ and for $t = o$ we get

$$o = h_1 - R \cdot \sin 2\gamma$$

$$c_1 = \frac{R}{2T_0} \sin\gamma \sqrt{\left(\frac{2T_0}{T_1}\right)^2 + 1}$$

because $\frac{1}{T} = \frac{1}{2T_0}\sqrt{\left(\frac{2T_0}{T_1}\right)^2 + 1}$. See equation (38).

The time t_x when $x = x_{max} = X$ ($\frac{dx}{dt} = o$) is computed from

$$\frac{t_x}{T_1} = \gamma - \beta = \pi - \gamma. \quad \text{Therefore}$$

$$X = h_1 + R e^{-\frac{T_1}{2T_0} \cdot \frac{t_x}{T_1}} \sin(\beta + \gamma - \beta)$$

and, as $\frac{T_1}{2T_0} = ctg\,\gamma$

$$X = h_1 + R e^{-(\pi - \gamma)\, ctg\,\gamma} \cdot \sin\gamma \quad (96)$$

and we can first determine γ with

$$R = \frac{h_1}{\sin 2\gamma}; \quad \cos\gamma \cdot e^{+(\pi-\gamma)\, cotg\,\gamma} = \frac{1}{2\left(\frac{X}{h_1} - 1\right)}$$

Is γ with this equation computed, we have for the other values

$$R = \frac{h_1}{\sin 2\gamma}; \quad 2T_0 = \frac{R}{c_1}\sqrt{tg^2\gamma + 1} = \frac{R}{C_1 . \cos\gamma};$$

$$T_1 = \frac{2T_0}{tg\,\gamma}; \quad \frac{1}{T} = \sqrt{\frac{1}{(2T_0)^2} + \frac{1}{T_1^2}}.$$

These values may then be introduced in the formulas for

$$x \text{ and } \frac{dx}{dt} = s \quad - \quad - \quad - \quad (94)$$

If the movement so determined must be similar to that which occurs if $h = u^1 \frac{L}{P} \cdot \frac{v^2}{2g}$, then the velocities $v = s\frac{A}{a}$, which we get for the same elevation x in both cases, must have the same values. If these values are not exactly equal, but if we get approximately equal values it depends on the degree of approximation desired whether we use the supplementary formula (92) or not.

In order to investigate this case, we proceed to compute the example.

With $X = 17.81$ feet $h_1 = 9.6$ feet we get

$$\cos\gamma\, e^{+(\pi - \gamma)\, cotg\,\gamma} = \frac{1}{2\left(\frac{X}{h_1} - 1\right)} = .581 \quad \gamma = 71^\circ\, 50'$$

$$\beta = 2\gamma - 180^\circ = -36^\circ\, 20'; \quad tg\,\gamma = \frac{2T_0}{T_1} = 3.047;$$

$$R = \frac{h_1}{\sin 2\gamma} = 16.2 \text{ feet with } c_1 = 0.098 \frac{\text{feet}}{\text{sec.}}$$

$$2T_0 = \frac{R}{c_1} \sin\gamma \sqrt{tg^2\gamma + 1} = \frac{R}{c_1} tg\,\gamma = 500 \text{ sec.}$$

$T_1 = 164.3$ sec. $T = 155.9$ sec. t_x $(x = X) = 310$ sec.

$$\text{and therefore } x = 9.6 + 16.2\, e^{-\frac{t}{500}} \sin\left(\frac{t}{164.3} - 36^\circ\right)$$

$$s = \frac{16.2}{155.9} e^{-\frac{t}{500}} \sin\left(71^\circ\, 50' + \frac{t}{164.3}\right); \quad v = \frac{s . A}{a} = s \times \frac{5380}{80}$$

With these formulæ, we may compute the relative values of x, s and v for the different values of t. From the supplementary formula (92)

$$v^2 = v_2^2 + \frac{D^2}{B^2}\left(1 - \frac{x}{D} - e^{-\frac{x}{D}}\right) \quad - \quad (92)$$

we may compute the values of v for the same values of x or they may be determined graphically from Fig. 12. They correspond to the assumption that $h = u^1 \frac{L}{P} \cdot \frac{v^2}{2g}$ and we get the following table of values:

t Sec.	o	50	100	150	200	250	300	310
x feet	0	4 06	9.21	12 9	15 7	17.4	17.8	17.81
s feet / sec.	.098	.092	.082	.0623	.0425	.023	.00328	.00

and from that

v feet / sec.	6.63	6.25	5.49	4.23	2.92	1.51	.20	.00

But from Formula (92)

v feet / sec.	6.63	6.3	5.38	4.05	2.83	1.35	.066	.00

If we plot in the rectangular co-ordinate system (Fig. 12) the two values of v as ordinates with the values of x

as corresponding abscissæ, then we see from the curves thus obtained that we may use the supplementary formula with sufficient accuracy for the determination of the movement. If we compare the values of T_0 and T as they have been found for both assumptions of h, that is to say, for T_0 the values 194.5 and 250.0 and for T the values 137.5 and 155.9, then we see that the second value of T_0 is 1.28 times as large as the first, the second value of T is $1.13 = \sqrt{1.28}$ times as large as its first value. The first values have been found from the formulæ $T_0 = \frac{L}{n.g}$ and $T = \sqrt{\frac{L}{g} . \frac{A}{a}}$ and from this we see the importance of the supplementary formula (92). It is evolved from the principal equation 15 if we introduce instead of L, a distance L^* which is 28% larger than L (provided that the value n is the same according to the relation $h_1 = n.v_1$) then with the distance L^*, we compute the values T and T_0. It is evident that with the introduction of the formula of resistance $h_1 = n.v$, the influence of the friction has been introduced in the equation as too large. We have, therefore, assumed in the supplementary formula the working capacity and, therefore, also the mass of the conduit volume, larger than they really are, but obtained the right value of the elevation through the supplementary formula. The friction height which corresponds to the elevation $X = 17.81$ feet can be obtained by computing the work balance, according to the former scheme, if we introduce the actual length of the conduit.

G becomes $5,380 \times 17.81 = 2,994$ tons;

$$y_1 = \tfrac{1}{2}\, 17.81 = 8.9 \text{ feet.}$$

USEFUL WORK IN FEET TONS		USED WORK	
15.800	KINETIC ENERGY OF CONDUIT VOLUME		
28,740	POTENTIAL ENERGY OF G = 2994t FOR h = 9·6		
	LIFTING WORK OF 2990t FOR 8·9'	26.650	TOTAL
TOTAL 44.540	FRICTION WORK	17,890	44,540

The total friction work of 17,900 foot-tons corresponds, therefore, to an average friction height with respect to the weight of the water of

$$h_{\text{average}} = \frac{17{,}900}{2{,}994} = .60\, h_1$$

For case (A) we found $h_{\text{average}} = .755\, h_1$ as the average value which corresponds to an elevation of only 16.75 feet actually. The maximum elevation above the initial level will be larger than 16.75 feet and smaller than 17.81 feet, therefore, $0.60\, h_1 < h_{\text{average}} < .755\, h_1$. The true value will be apparent if observation results in constructions of larger dimensions than can be obtained. We may remark also that the above determined values of T and T_0 in the supplementary formula are only correct for the first surge from $x = o$ to $x = X$. We may carry the mathematical investigation further and find the values for the drop from the first maximum elevation to the first minimum level. Other values for T and T_0 must be introduced, which correspond to smaller values of L^*. This repeats itself for the further phases of increase and decrease until finally L^* becomes nearly equal to L. This corresponds to the decrease of the velocity fluctuations during the movement and also with the decrease of the influence of friction.

Conclusions.

We may summarize our results as follows:

1. If the conduit ends in a pond, from which the penstock goes directly to the turbine, and if the area of the pond surface $A > 150.m.a$ where a = the conduit area in square feet and m the number of miles conduit length: we need not expect any periodical fluctuations of the outflow, even if the outflow varies during the observed time. If $A < 150\ m\ a$ as is the case with artificial surge tanks, such periodical fluctuations may occur.

2. The maximum elevation above the initial level (operation level for full outflow) has approximately the same ratio for a short time for a sudden as well as for a gradual close of the whole outflow.

3. The value of the maximum elevation above the initial level may best be computed by means of the work balance, where for the average friction height 0.7 of the value of that height h_1 must be introduced, which corresponds to the drop of the water surface in the surge tank below the level of the water surface before the conduit for full outflow.

4. The extent of drop below the static level for full opening is approximately equal to the rise above computed.

5. For the determination of the oscillations during and after completed shut-down, we may use for a fair degree of approximation the formulæ, computations and demonstration methods which correspond to the analysis above developed on the theory of damped oscillations. The values of T and T_0 and therefore also T_1 may be determined if investigating the maximum elevations, as shown in our last study.

6. For operation, which results in a periodical variation of the outflow, resonance features may occur.

7. The maximum elevations may be decreased by construction of spillways in the surge tank or in the conduit.

The theory furnishes a good explanation concerning the manner and the relative value of the operations close enough for most practical purposes. But a high degree of accuracy will be accomplished only where experiments furnish much more exact values for friction in conduits under different conditions.

Appendix A—Surge Tank With Variable Cross-section.

Assuming a quadratical relation between friction-head and conduit velocity the following relation was obtained. (See Formula 91.)

$$v^2 = v_2^2 - \frac{2g}{L.a}\, e^{-\frac{u^1 V}{P.a}} \int_0^V x\, e^{+\frac{u^1 V}{P.a}}\, dV \qquad (91)$$

The maximum surge is obtained by making $v^2 = o$ and solving the latter equation for X. The previously described graphical method may be applied without further comment to surge tanks of variable cross-section with the exception that the X curve is no longer a linear function of V. For this reason and because of complex integration due to the insertion of a complicated function the graphical method is more appropriate than the analytical.

In the following example this method is applied to a surge tank, circular in section, which has a sectional area of 5,380 sq. ft. at the operating level, as was assumed before. However, in this case the sectional area increases in direct proportion to the height in such a ratio that at a height of 19.7 ft. the sectional area is 6,450 sq.

ft. (See Fig. 14.) All other data for the problem is the same as assumed in the main article.

L = 9,050 ft.
a = 80 sq. ft.
p = 32.8 ft.
Q = 530 cu. ft. per sec.
v_2 = 6.63 ft. per sec.
P = 2.44
h_1 = 9.6 ft.
u' = .0038

$$\frac{u'}{P.a} = \frac{1}{51{,}300} = \frac{1}{a_2}$$

$$6.63^2 = 44.0 = \frac{64.4}{9050.80} e^{-\frac{V}{51{,}300}} \int_0^V x\, e^{+\frac{V}{51{,}300}} dV$$

With this graphical method (Fig. 13) a maximum surge of only 17.0 ft. is obtained, whereas in the former example, with a surge tank of a constant sectional area

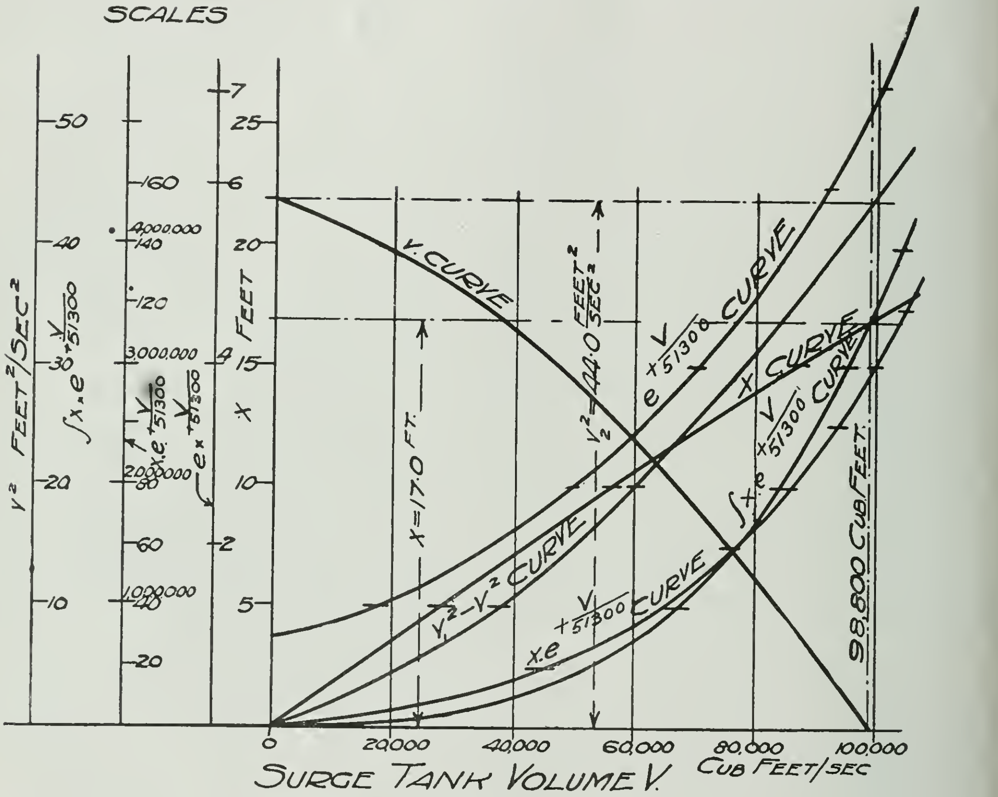

Fig. 13.

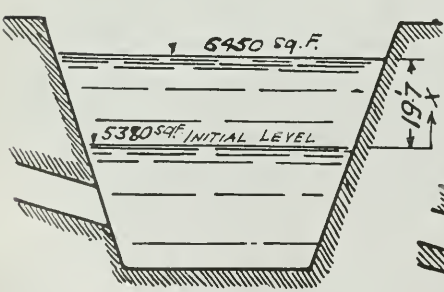

Fig. 14.

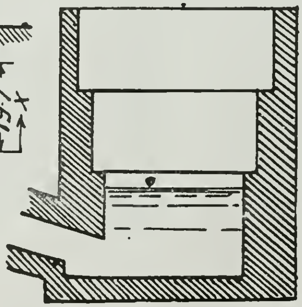

Fig. 15.

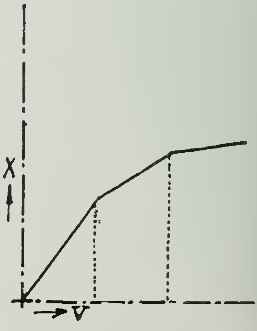

Fig. 16.

of 5,380 sq. ft. a surge of 17.8 ft. resulted. But the volume of water lifted is, in this case, somewhat greater, that is, 98,800 cu. ft., as compared to but 95,600 cu. ft. in the former case.

In the same easy way the graphical method may be applied to a surge tank in which the cross-section varies irregularly with the height. For instance, as the Albula plant of the city of Zurich. (Fig. 15.) In this a break occurs at the points on the x curve where the ratio between sectional area and height changes. (See Fig. 16.)

Appendix B—Simplified and Approximate Formula for the Determination of Surge Tanks With Constant Cross-Section.

By A. Strickler.

The designing engineer must often consider several solutions for one problem and from these select the best for the actual work. For these preliminary investigations he is in need of a simple slide-rule formula. In the following such a formula will be derived for the required area of a surge tank with given maximum surge.

As initial formula, equation 51 may be used for a sud-

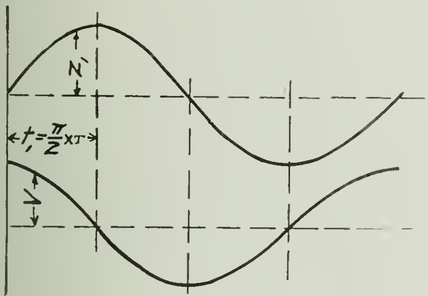

Fig. 17.

den full shut-down.

$$\frac{M \cdot v_1^2}{2} + G \cdot h_1 = G \cdot y_1 + A^1 \qquad (51)$$

The notation being the same as before, the average friction head in the surge tank for the first surge may be called h_a. Equation 51 can now be written:

$$-\frac{w.a.L}{2g} \cdot v_1^2 + G\left(\frac{y_{max}}{2} - h_1\right) + G \cdot h_a = o$$

$$-\frac{a.L.v_1^2}{2g} + \frac{A.y^2_{max}}{2} - A.y_{max}.h_1 + A.y_{max}.h_a = o \qquad (51a)$$

since $h = \frac{u^1.L}{P.2g} \cdot v_1^2$; $\quad h_a = \frac{1}{t_1}\int_0^{t_1} h.dt$

$$= \frac{1}{t_1}\int_0^{t_1} \frac{u^1.L\,v_1^2}{P.2g}.dt \qquad (51b)$$

t_1 = time from the beginning of the surge to the moment of maximum elevation. In order to integrate equation 51b, v must be known as function of t. The simplifying assumption is now made that the first part of the v curve is a regular cosine curve. This would be true if the water level fluctuations were an undamped harmonic of the form

$z = C \,.\, \sin\left(\frac{t}{T}\right)$ (see Fig. 17).

Making the above assumption

$$v = \frac{s.A}{a} = \frac{A}{a}.\frac{dz}{dt} = \frac{A}{a}.\frac{C}{T}.\cos\left(\frac{t}{T}\right)$$

and also $\quad v_1 = \frac{A}{a}.\frac{C}{T}.\cos\frac{o}{T} = \frac{A}{a}.\frac{C}{T}$

$$v = v_1 \cos\frac{t}{T}; \qquad h = h_1 \,.\, \cos^2\left(\frac{t}{T}\right)$$

Substituting these values in equation (51b) there results:

$$h_a = \frac{1}{t_1}\int_0^{t_1} h_1 \,.\, \cos^2\left(\frac{t}{T}\right) dt = \frac{h_1}{\frac{\pi}{2}T}\int_0^{\frac{\pi}{2}T} \cos^2\left(\frac{t}{T}\right) dt \qquad (51c)$$

$$= \frac{h_1}{\frac{\pi}{2}.T} \times \frac{\pi.T}{4} = \frac{h_1}{2} \qquad \therefore \qquad h_a = \frac{h_1}{2}.$$

The average friction head in the tank for the time up to the maximum surge is therefore equal, under the above mentioned assumption, to half the friction head which exists in the conduit during operation. This value of h_a introduced into equation 51a (work balance) gives:

$$-\frac{a.L}{2g}.v_1^2 + \frac{A}{2}.y^2_{max} - A.y_{max}.h_1 + \frac{A.y_{max}.h_1}{2} = o$$

$$\text{or } A = a \,.\, \frac{\frac{L}{g}.v_1^2}{y_{max}\,(y_{max} - h_1)} = \frac{a\,\frac{L\,.\,v_1^2}{g}}{(z_{max} + h_1)\,z_{max}}$$

$$\therefore A = \frac{a.v_1^2}{2g}.\frac{2L}{(z_{max} + h_1)\,z_{max}}.$$

This formula gives results somewhat too large (1% to 3%) but is exact enough for preliminary computations.

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Speed regulation in hydro-electric plants. By Wm. F. Uhl. A.S.M.E. Pamphlet No. 1354. Year 1912. A survey of the methods used for the speed regulation of turbines.

The surge tank in water power plants. By R. D. Johnson. A.S.M.E. Pamphlet No. 1204. Year 1908. Contains the theory of the differential surge tank.

Wasserschlossprobleme. By Franz Prasil. Schweizerische Bauzeitung, Vol. 52, 1908. Authorized translation by E. R. Weinmann and D. R. Cooper. *The Canadian Engineer*, Vol. 27, 1914.

Druckschwankungen in Turbinenzuleitungsrohren. By A. Budau. Zeitschrift des oestreichischen Ingenieur- und Architektenvereins, year 1905. A mathematical analysis of pressure variation in pipe lines.

Beitrag zur Bemessung des Inhalts von Wasserschloessern. By Konrad Pressel. Schweizerische Bauzeitung, Vol. 53, 1909. A short study of the laws governing the water fluctuations in surge tanks.

Allgemeine Theorie ueber die veraenderliche Bewegung des Wassers in Leitungen. By Lorenzo Allievi and Robert Dubs. Berlin, 1909, Julius Springer. A mathematical analysis of the hydro-mechanic problems involved in pressure conduits.

Zur Theorie des Wasserschlosses bei selbsttaet'g geregelten Turbinenanlagen. By Dieter Thoma, Muenchen, 1910. R. Oldenburg. Containing an analysis of resonance phenomena.

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Water hammer experiments. By M. R. Lott. Engineering Record, October, 1912.

The surge tank at San Francisquito power station No. 1, with discussions by R. D. Johnson, Roy Taylor and W. F. Durand. Engineering Record, years 1913 and 1914.

Versuche ueber Druckschwankungen in eisernen Rohrleitungen. By A. Strickler. Schweizerische Bauzeitung, Vol. 64, 1914, (Laboratory tests).

NOTE.

The article "Surge Tank Problems" will be issued at a later date in pamphlet form. A note will appear in *The Canadian Engineer* when ready for delivery.

PANAMA CANAL OPENED.

The United States War Department steamship "Ancon" has made the passage through the Panama Canal, and transit through the waterway is now officially open to the traffic of the world. The "Ancon" made its way from its berth at Cristobal to the end of deep water channel from the Atlantic to the Gatun Locks. It went through the locks, which have a lift of 85 feet, in 70 minutes. It continued through the waterway, from deep water on the Atlantic to deep water on the Pacific side, without incident.

Vessels drawing not more than 30 feet of water and up to 10,000 tons register may now make the passage. It will be possible to put some of the big American dreadnoughts through at any time.

Facts About the Canal.

Total length of canal, 50 miles.
Salt water, channel to Gatun Locks, 7 miles
Fresh water, Gatun Lake and Culebra Cut, 33 miles.
Fresh water, Pedro Miguel Lock to Miraflores Locks, 1½ miles.
Salt water, Miraflores Locks to Pacific, 8½ miles.
Width of channel, 300 to 1,000 feet.
Minimum depth, salt water, 40 feet.
Minimum depth, fresh water, 41½ feet.
Total angles in canal, 600d 51m.
Sharpest angle, Tabernilla, 67d 10m.
Work begun by Americans, May 4, 1904.
Number of men employed, average, 40,000.
Steam shovels employed, 101.
Locomotives employed, 307.
Drills employed, 4,572.
Railway cars employed, 4,572.
Dredges employed, 20.
Cranes, piledrivers, barges, tugs and miscellaneous machines employed, 263.
Total cost, $375,000,000.
First vessel through Gatun Locks, Sept. 26, 1913.
Water let into Culebra Cut, Oct. 1, 1913.
Gamboa dike blown up, Oct. 10, 1913.
First vessel through Miraflores Locks, Oct. 14, 1913.

Culebra Cut.

Length, 9 miles.
Width at bottom, 300 feet.
Width at top, ¼ to ½ mile.
Deepest excavation, 495 feet.
Average depth of excavation, 120 feet.
Excavated by French, 20,419,720 cubic yards.
American excavation, estimate, 89,794,493 cu. yds.
Added excavation, account of slides, about 22,000,000 cubic yards.
Day's record for one steam shovel, 4,823 cubic yards.
Largest slide, Culebra, 10,000,000 cubic yards.

Gatun Dam.

Length, 8,000 feet.
Width of base, 2,100 feet.
Width at water level, 400 feet.
Width at top, 100 feet.
Height, 115 feet.
Volume of rock and clay, 22,100,000 cubic yards.

Gatun Lake.

Area, 164 square miles.
Height of surface above sea level, 85 feet.
Water capacity, 183,000,000,000 cubic yards.
Area of watershed, 1,320 square miles.
Minimum depth, rainy season, 47 feet.
Minimum depth, dry season, 39 feet.

Gatun Locks.

Length over all, 3,500 feet.
Width over all, 350 feet.
Volume of concrete construction, 2,043,730 cu. yds.
Width of side walls at base, 52 feet.
Width of side walls at top, 8 feet.
Width of centre walls, 60 feet.
Height of walls, 81 feet.
Dimensions of lock chambers, 1,000 x 110 feet.
Depth of water in lower lock chambers, 40 feet.
Depth of water in upper lock chambers, 41½ feet.
Length of lock gate leaves, 65 feet.
Height of lock gate leaves, 47.4 to 82 feet.
Weight of largest gate, 1,483,700 pounds.

Editorial

DEPRESSION AND DUTY.

Governments and municipalities, corporations and individuals should strive at this time to remember the natural virtues—justice, prudence, temperance and fortitude. The theological virtues—faith, hope and charity—are equally important, but they will follow without effort if the natural virtues are exercised.

Justice demands that all men who are willing to work be given work.

Prudence requires careful avoidance of extravagance and equally careful avoidance of panic that might be caused by unnecessary retrenchments and false economies.

Temperance embodies rational self-control. It means the suppression of any tendency to thoughtless actions. It implies the calmness and patience that were never more essential in Canada's history than at present.

Fortitude calls for resolution and constancy. It is demanded when the evils of trade depression and war are encountered, if they are to be overcome and transformed into opportunities.

No men in Canada are able to recognize these broad principles of philosophy better than the technically trained and those whose experience has been in handling large numbers of men. Therefore the engineers and contractors have a duty that they should remember. They should be leaders in thought, leaders in action. No man in a community to-day should be bigger than its city engineer, for instance. And the engineers and contractors must direct public thought and action into sane, philosophical, business-like channels.

RAILROADS FAVOR GOOD HIGHWAYS.

Public roads are an indispensible part of the transportation system of Canada, supplementing the railroads and waterways. That this is well recognized by the railroad officials is evidenced by recent remarks made by President Harrison of the Southern Railway Company.

Speaking of the relation of the country highway to the railroad, Mr. Harrison said: "Whatever may be the final destination of the farm products, their first movement must be over the country road, and if the farmer is to receive the largest measure of benefit from good roads, the policy should be adopted of improving those highways which radiate from market towns and shipping stations and over which the farmers must haul their produce. The profit which will be earned by the farmer may depend largely upon the condition of the road from his farm to a shipping station. With good roads he can not only haul heavier loads in shorter time but, except as to perishable commodities, he can market his produce when prices are most favorable and can do his hauling when it is most convenient, and even when the ground is too wet for work in the fields.

"The manifold advantages of an improved highway in reducing the cost of drayage, facilitating social intercourse, promoting school and church attendance, expediting rural mail delivery, increasing the value of farm lands, and promoting agricultural development back from the railroads, are so great that they need but to be enumerated to present a convincing argument in favor of road improvement.

"Several years ago the Southern Railway Company, in conjunction with the United States Agricultural Department and State and local authorities, operated over its lines a good roads train, carrying machinery and lecturers, and building at central points object-lesson roads. This was accelerated in 1911 by the operation of another good roads train in co-operation with the United States Department of Agriculture and the American Highway Association."

CO-OPERATING WITH COMPETITORS.

Trade is rapidly becoming civilized. Corporations, like individuals, have learned that it pays to apply the Golden Rule. No better example of the benefits of proper association of interests could be found than the eleventh annual meeting of the National Paving Brick Manufacturers' Association at Buffalo last week.

The aim of brick manufacturers formerly was to advance as much as possible by individual effort, each plant jealously keeping its competitors in the dark regarding any improvements in machinery or methods, each engineer regarding his knowledge and his experiments as strictly private property.

The result was brick that was not dependable, not uniform, not standard. Co-operation, better ideas, and more liberal business policies have changed all this. Largely through the work of the association mentioned, paving brick has been brought up to a high standard and is being manufactured more efficiently and more economically.

Over two hundred and fifty brick manufacturers and guests, among whom were many municipal and highway engineers and road contractors, attended the meeting. The business sessions were completed on the first day, and the following two days, Thursday and Friday, were devoted to inspections of brick highways in and near Buffalo. There was a free exchange of ideas, both in regard to manufacturing processes and methods of construction. The relative advantages of bituminous and cement grout fillers; the necessity or otherwise of transverse expansion joints, and the best fillers to use if such joints are left in the pavement; the advisability or inadvisability of longitudinal expansion joints at each side of the road, and the advantages therefor of bituminous fillers and of creosoted wood strips—these and scores of other problems of great interest to highway engineers were discussed informally, and many of them practically settled by concensus of opinion.

The discussions were extremely valuable, because over half the men present were brick highway experts—men like "Bill" Perkins, formerly resident engineer at Buffalo for the New York State Highway Commission; Frank Dunn, of Dunn-Wire-Cut-Lug-Brick fame; Will P. Blair, the association's energetic secretary; and scores of other men who, like those mentioned, have built hundreds of miles of brick roads.

The meeting was by no means entirely one of self-admiration, however. It was realized that there is serious work still to be done by the association to perfect brick and methods of brick construction. For in-

stance, the announcement of the State Highway Commissioner of Illinois that he is building 82 miles of road—12 miles of brick and 70 miles of concrete—reminded the members of the association that there are engineers who believe that in building a brick road with cement filler, the bricks should be laid a mile apart.

LETTER TO THE EDITOR.

British Manufacturers Showing Courage.

Sir,—We want to ask you to help us and other British engineering manufacturers by putting a note in your journal explaining that we are keeping our shops going notwithstanding the war, and want all the orders we can get from Canada.

Everybody here appreciates the enormous help we are getting from Canada in men and food, but we want your readers to help to keep our industries alive, so that we can keep the wolf from the door. If Canadians will make a determined effort to send their orders to the old country instead of to the States, it will be invaluable.

Bear in mind that about 25 per cent. of our men are with the forces now and that the rest of us must earn their keep, for the firm has undertaken to pay half salaries and wages to all men who have joined, as well as to keep their places open, and most other firms are doing the same.

We cannot expect to give quite such good deliveries just now as usual, but that is exactly where we look to Canadian buyers to stretch a point.

Sydney (Australia) has set a good example. The corporation had placed an order for a 5,000 kw. turbo-generator with a German firm at a "dumped" price. They have cancelled that order and have placed the work with us at our price and, what is more, they are going to pay us instalments as work proceeds in our shops.

WILLANS & ROBINSON, Limited.

Rugby, England, August 31, 1914.

PERSONAL.

R. H. SPERLING has been appointed assistant to the chairman of the B.E. Electric Railway company, in London, Eng.

WM. C. ROWSE, B.Sc., M.E., has been appointed to the chair in the University of Manitoba, as professor of mechanical engineering. Professor Rowse is a graduate of Purdue University.

H. P. MAYBURY, M. Inst. C.E., in November of last year appointed to the office of Chief Engineer of the British Road Board, has been elected to the newly created position of Manager and Engineer.

M. A. WOODS, recently assistant chief engineer of the G.T.P. Railway system, has been appointed to the position of chief engineer, left vacant by the resignation of Mr. B. B. Kelliher. Mr. Woods' headquarters will be at Winnipeg, Man.

M. C. FLINT, formerly assistant engineer in the construction department of the C.P.R. company, and engaged on branch line and double-track construction, has been appointed resident engineer of district No. 4 of the Alberta division of the C.P.R. system. Mr. Flint's headquarters are at Edmonton, Alta.

JAMES A. MacGREGOR has been recently promoted by the C.P.R. company to a position as district superintendent on the company's Alberta division. Mr. MacGregor's headquarters are Edmonton, Alta. His last office with the railway staff was that of a relieving superintendent on various divisions of the system.

THOMAS ADAMS, the noted town planning expert of the British local government board, is being brought to Canada by the Conservation Commission to act in an advisory capacity. Mr. Adams will arrive in Canada early in October. He will collect information for the commission relative to various Canadian municipalities, and his services will be available to any of them.

L. E. ALLEN, Belleville, Ont., county engineer for Hastings; A. W. ELLSON FAWKES, Calgary, Alta., waterworks engineer; E. C. A. HANSON, Saskatoon, Sask., city electrical engineer; G. H. HATFIELD, St. John, N.B., road engineer; W. MURDOCH, St. John, N.B., city engineer; and G. D. WEAVER, Melfort, Sask., are Canadian names appearing on the most recently published list of members of the Institution of Municipal Engineers (Great Britain).

GEORGE W. COBURN, recently appointed a resident engineer for the C.P.R. company, and located at Brandon, Man., began service with the company in 1896, and since that year, has received the following promotions: from 1896-1900, roadsman and draughtsman at Farnham, Que.; 1901-1907, draughtsman and assistant district engineer, Souris and Brandon, Man., and Moose Jaw, Sask.; 1907-1914, district engineer and resident engineer, Souris and Brandon, Man.

OBITUARY.

The death occurred on August 30th in New York of William De Hertburn Washington, a prominent member of the American Road Builders' Association. He was a member of the American Society of Civil Engineers, and, at one time, was United States consul at London, Ont. Twenty years ago, he went to New York and became President of the Hydraulic Construction Co. Mr. Washington took a prominent part in the Third International Road Congress, held at London, Eng., in June of last year, and also in December at the Philadelphia convention of the American Road Builders' Association.

Word reached the Department of Railways and Canals, Ottawa, on September 10th, of the death caused by drowning on August 25th of James Wilson, an engineer in the employ of the government for the past two years on the Hudson Bay railway construction.

COMING MEETINGS.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Charles Carroll Brown, Secretary, Indianapolis, Ind. Meets at Somerset Hotel, Boston, Mass., October 21st, 22nd and 23rd.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

Volume 27. Toronto, September 24, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

BRIDGE ACROSS THOMPSON RIVER, LYTTON, B.C.

A FEW ILLUSTRATIONS AND A SHORT DESCRIPTION OF THE CONSTRUCTION OF THE NEW BRIDGE COMPLETED IN JUNE, 1914, BY THE PROVINCIAL GOVERNMENT, AND SPANNING THE THOMPSON RIVER AT LYTTON, B.C.

IN August of last year, the government of British Columbia commenced the construction of a bridge, which was designed by E. A. Stone, M. Can. Soc. C.E., M. Inst. C.E., Consulting Engineer, Vancouver. The structure was erected under the supervision of J. E. Griffith, Deputy Minister and Chief Engineer of the Provincial Department of Public Works, and was completed in June, 1914. It crosses the Thompson River, just above the junction with the Fraser, at a site lying between that of the old government's wooden bridge and the crossing of the Canadian Northern Railway. Fig. 1 illustrates the former structure and also shows in contrast the old and new bridges. The superior excellence in the appearance of the latter is self-evident, as is also the added height of level, that of the new bridge being 40 feet above that of the old.

The contract for both the supply of the material for the sub-structure of the bridge as well as for the entire construction was awarded by the government to the Graff Construction Company. The material used was concrete, and of that 2,000 yards were required. This concrete rests on a rock foundation, which is dry at extreme low water; and was deposited by means of buckets suspended from a cable running across the river, as shown in the

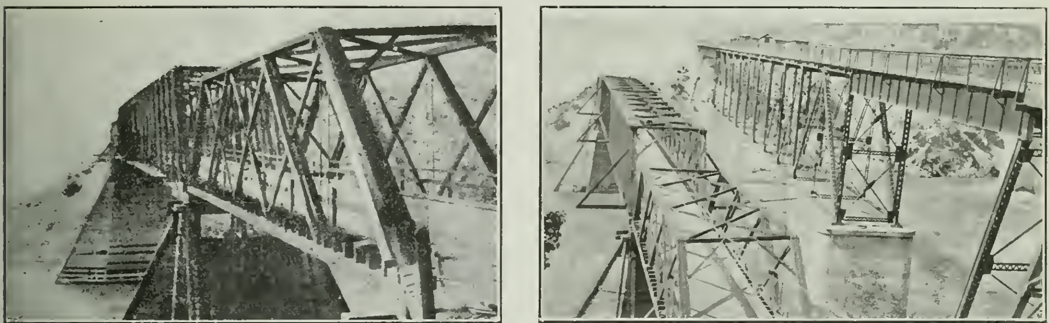
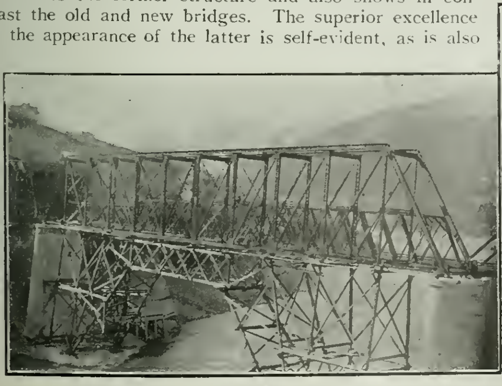


Fig. 1.—Old and New Bridges in Contrast.



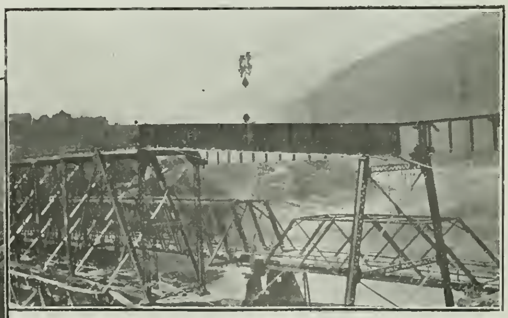


Fig. 2.—Falsework for Erection of 250-Foot Span. Plate Girder Span Being Placed by Cableway.

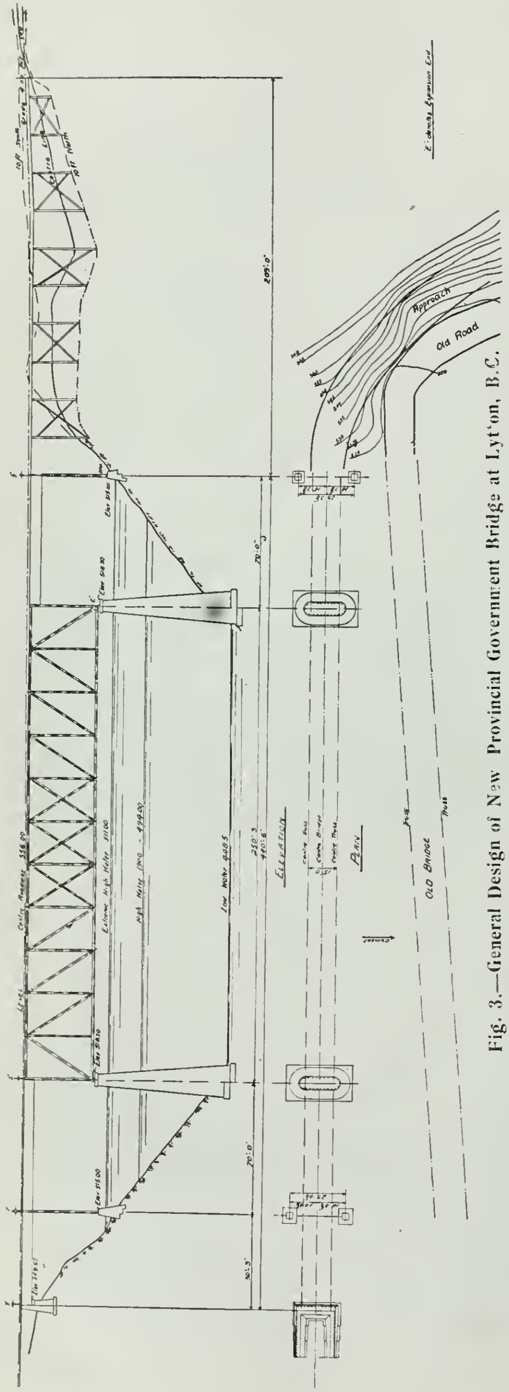


Fig. 3.—General Design of New Provincial Government Bridge at Lytton, B.C.

first and second sections of Fig. 5. The concrete was mixed to a consistency of 1 : 3 : 5, and, when completed, made a sub-structure of both satisfactory strength and very creditable appearance.

Fig. 3 shows the general plan of the new bridge as proposed and constructed; and Fig. 4, sections of the concrete abutments carrying the main truss span and of the trestle forming the approaches. As may be seen in the third section of Fig. 5, which indicates the progress made upon the south pier of the bridge by January 19, 1914, a timber trestle approach, 209 feet in length together with a similar length of grading, had to be built on the southeastern bank of the river. The concrete piers of the abutments which carry the main truss span of the bridge are 70 feet above low water, the distance of the resting surface of the truss above the extreme high-water level being 7½ feet. The large truss span resting upon these piers is 250 feet in length and 35 feet in depth (Figs. 1 and 2); while there are also two 70-foot plate girder spans, one on either side of the main section, and in addition a 50-foot plate girder span carried on steel

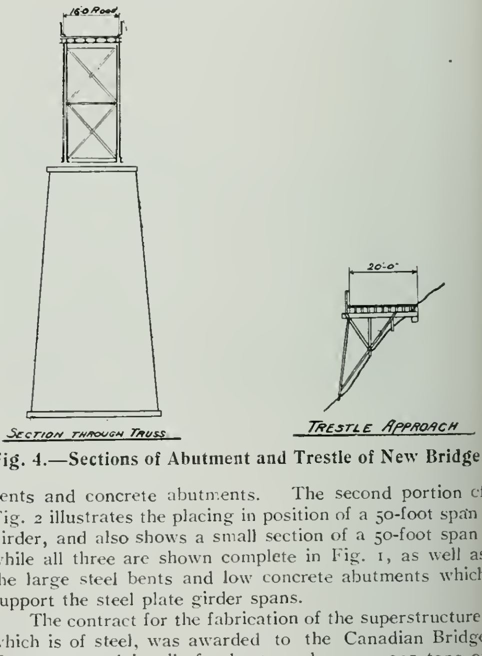


Fig. 4.—Sections of Abutment and Trestle of New Bridge.

bents and concrete abutments. The second portion of Fig. 2 illustrates the placing in position of a 50-foot span; girder, and also shows a small section of a 50-foot span; while all three are shown complete in Fig. 1, as well as the large steel bents and low concrete abutments which support the steel plate girder spans.

The contract for the fabrication of the superstructure, which is of steel, was awarded to the Canadian Bridge Company; and in all, for bents and spans, 215 tons of material were required. The bridge was so designed that the combined strength of the concrete and steel work would be capable of carrying a live load of 75 pounds to the square foot on the 250-foot truss and 100 pounds to the square foot on the 70- and 50-foot spans, together with a concentrated load of a 16-ton road roller.

The roadway of the bridge is 16 feet in width and has been constructed of 4-inch plank protected on either side by a 4-foot hand railing with posts 7 feet 7½ inches apart. The roadway plank is supported on 6-inch joists of varying depth, according to camber, on steel I-beam stringers, while a crowning, one inch thick, has been applied to the top of the floor.

By September 1, 1913, the Graff Construction Company, contractors for the bridge, had advanced to the

stage indicated in the first section of Fig. 5. The north abutment was in place; the cable-way erected, and the bucket had commenced the depositing of the concrete mixture for the formation of the piers; in October, this abutment was completed and the pedestals for the steel of the bridge work in progress in Fig. 2 were taken on April 15 and April 22, the former portion of the illustration showing the falsework used in the erection of the main span, perhaps the most interesting feature in connection with the building of the bridge, the falsework

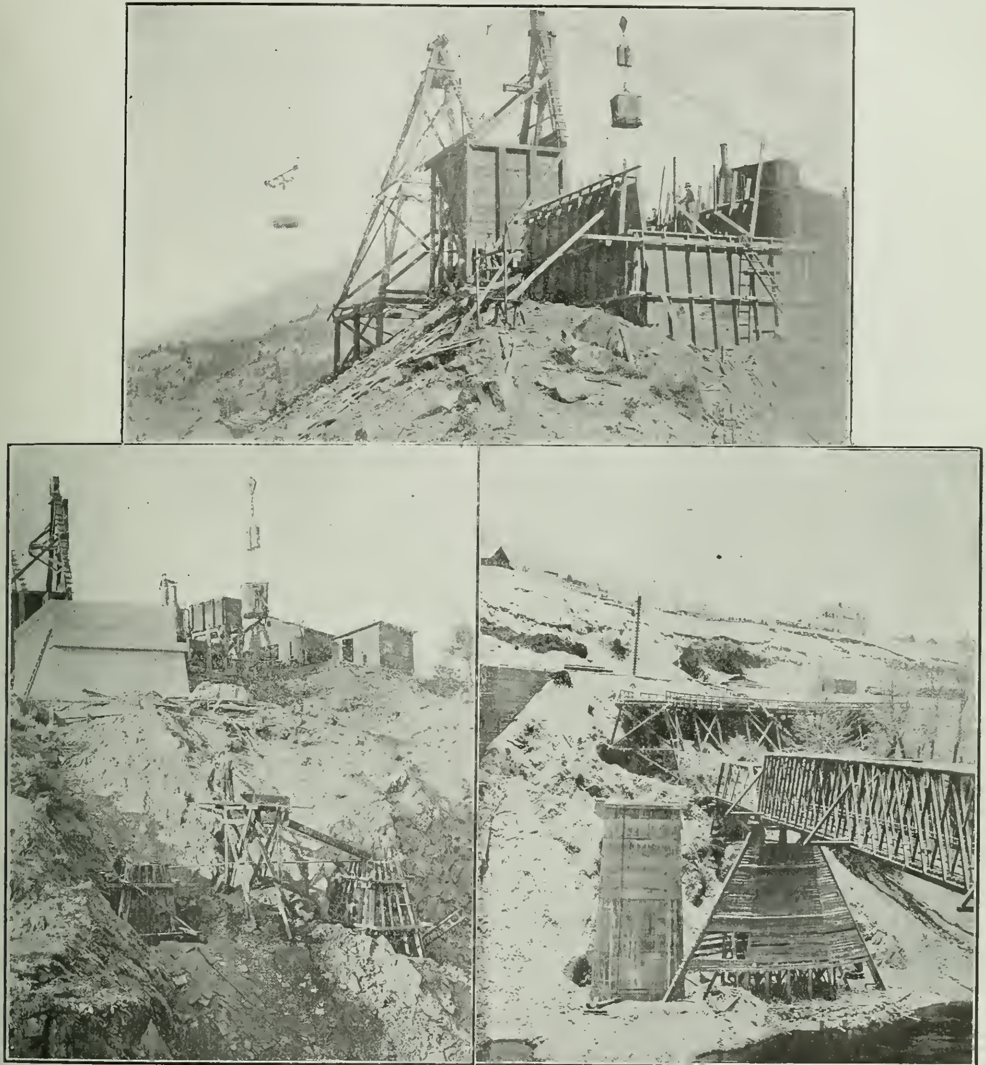


Fig. 5.—North Abutment in Place, Cableway and Bucket. North Abutment Completed and Pedestals of Steel Bent. South Pier and Timber Trestle Approach.

bent constructed, as shown in the second section of the same figure. The timber trestle approach on the south-eastern shore, shown in the distance in the third section, was completed early owing to the fact that the contractors were obliged to wait for lower water before commencing to build the main piers; and by January 19, 1914, the south pier had reached the stage of advancement also indicated in the last section of Fig. 5. The photographs extending from each shore and carrying a Howe truss in the centre; and the latter, descriptive of the erection of the steel superstructure, all of this being placed by means of a cableway. The structure was completed finally and opened for traffic in June, 1914.

Reference was made to the design of this bridge in *The Canadian Engineer* for July 17th, 1913.

OUTFALL SEWER CONSTRUCTION.*

By James Munce, M. Inst. C.E.,
Deputy City Surveyor, Belfast, Ireland.

In order to purify (where necessary) and dispose of sewage it must first be collected. The object of this paper is to ask engineers to take into consideration this particular section of their work, and leave for a little the chemists and bacteriologists to deal with the sewage itself which the engineers have collected for them in the place most convenient for getting rid of it, or of the effluent they leave us to dispose of.

As every portion of the country which is not a lake or marsh drains by gravitation to the sea, there is not except under very exceptional circumstances, any great genius displayed in designing a scheme entirely depending on pumps.

A town does not of necessity remove the natural watercourses, but there is no doubt the extension of buildings and streets with impervious surfaces sends the water more rapidly into the outlets, natural or artificial, provided for it. In fixing the sizes of sewers the sewage is the smallest item to be provided for, and the rainfall or surface water is the volume which needs most careful consideration.

The growth of the area within a reasonable period, and the increased use of water as the population increases, both in opulence and numbers, must not be forgotten. Many communities which a few years ago considered 25 gallons per head an ample supply now use 50 gallons. As sudden rainfalls often multiply the volume to be dealt with by 12 to 15, the positions of storm overflows and their possible effect on the streams or other outlets into which they discharge require careful study.

The problem in Belfast has been one of extreme difficulty. A large area of the city has been reclaimed from the sea, and many acres are so far below high-water level that they are only kept from daily flooding by the quay walls, which are 0.6 ft. above the highest recorded tide and 4 ft. above ordinary high water. Formerly the sewers all discharged into the harbor or into rivers which in turn discharge into it; they were protected by valves, and only discharged on the last half of the ebb tide. These have now been intercepted, and the area drained by them, and also the whole of the County Down portion of the city, 5,400 acres, form the low-level drainage area. It will be seen that as no storm overflows are available from the lower portion of this area except at and near the time of low water, storm pumps to relieve the sewers are unavoidable. The intercepting sewers extend for about 3 miles on the County Antrim side of the river, and rather more on County Down side, through lanes and streets made on the reclaimed areas; they have a fall of at least 2 ft. per mile, and on the portions nearest the river are almost entirely through alluvial deposits known locally as "sleetch," or in-filling of all kinds deposited inside the reclamation embankment.

The difficulty of construction in ordinary filling was of the usual kind met with in such material, and is not further referred to. The sleetch is a remarkable material; when dry it crumbles like fine sand; with a little moisture it swells and becomes like a soapy clay; with a quantity of water it has the consistency of soft dough.

The main outlet sewer was constructed for a mile in slob lands of sleetch, which are dry at low water, but covered from 2 ft. to 6 ft. at high water. As an example of the unstable nature of this sleetch, it may be mentioned that when the author was making the surveys for the scheme in 1886 he put a man out of a boat on the apparently firm bank of a channel to fix a pole; he sank so quickly in it that he was rescued with difficulty, yet when the work was being carried out this same bank proved one of the firmest places met with and most difficult to excavate.

When the scheme was laid before Parliament it provided for four cast-iron pipes, each 4 ft. in diameter, surrounded by concrete, as the outfall sewer into the sea, one-fifth of a mile in length.

The landowners on the lough side objected to the position of the outlet and opposed the Bill. The corporation directed their consulting engineer to meet the adviser of the opponents, both very eminent in their profession, and settle the matter amicably. They agreed to omit the iron pipes, and construct instead a wooden double trough 1 mile long under the slob, with its outlet in deep water. This chute, as it was termed, is constructed of pitch-pine, which was shipped at Galveston, already cut to the scantlings required and floated from the vessel direct to the work. The method of construction was as follows: Two rows of sheet piles were driven of a length sufficient to form a half-tide dam, and constituted the permanent outer sides. The range of tide is 8 ft. in Belfast. When a length of 100 ft. or so had been driven, a cross-dam was formed, and when the tide had fallen to the level of pile heads the dam was pumped out and the excavators had about six hours' work before the tide rose over the piles again. When a length had been excavated the centre piles were driven, and the construction of the woodwork completed. When a length was finished, the pile sides forming the half-tide dam were cut off and were sufficiently long to form the centre piles for another length. In due time the chute was completed. During the past twenty-five years it has cost a great deal to repair. Many remedies were proposed for it. Hundreds of tons of old concrete were placed on its top, and strong piles fixed to keep it in its place. It is still there, but is unsatisfactory. A ferro-concrete outlet sewer is now being constructed alongside it; when this has been completed the old wooden one will be abandoned.

Lessons to be drawn from the experience gained are that compromises made between rival consulting engineers in the short time available during the progress of a Bill before a Parliamentary Committee are not always satisfactory, and that the considered design of an engineer who knows local conditions should not lightly be set aside.

This new outlet sewer through the slob lands will be in progress for more than another year, and is well worth a visit by any who can afford the time.

The present city surveyor carried out the repairs to the 5,500,000 gallons storage tanks constructed on the slob in a very ingenious way. These tanks were leaking and cracked in the bottom and sides; to rebuild them would have probably cost £40,000, besides the terrible upset to the whole outfall of the sewers. He took one tank at a time and forced cement grout into the crevices and under the floor; altogether 1,120 tons of cement were used. It was mixed with an equal quantity of sand, and was put in under air pressure varying from 7 lbs. to 15 lbs. per square inch. The reservoir is now quite watertight.

Excavations recently made alongside it show that the grout found all the crevices in the foundation and followed them through the sleetch, even 4 ft. beyond the outer walls.

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* From a paper read before the Blackpool (Eng.) Congress of the Royal Sanitary Institute.

The outfall sewer from junction of the high-level and low-level sewers at No. 1 pumping station to the outfall works is laid along the centre of an embankment about 150 ft. wide, formed of dredgings and sleetch lifted from the harbor during the previous twenty years. There is a timber pond on each side. When the sewer was commenced this embankment was comparatively dry, and the trench stood without timbering; those in charge were charmed, and for a week or two boasted of how cheaply the work was being constructed. Alas for their hopes! A few wet days changed all this, and sheet piling had to be adopted and left in for the entire length of the work to keep the sewer in line. Notwithstanding this precaution the arch cracked from end to end, and had to be made good before the sewer could be used. Some portions of it have spread, and had to be replaced recently. A road 50 ft. wide is now made along the embankment, and forms the approach to the outfall works.

As a relief to the main outfall sewer, and to make it available in times of storm for the increased volume flowing from the high-level area by gravitation, it was arranged to lay a 4-ft. diameter pumping main direct from No. 1 pumping station to the outfall works, a distance of about 1,000 yds.

Before deciding on the use of steel pipes careful examination was made of similar pipes which had been in use for some time as a sludge main from the tanks to the jetty where the steamer is loaded, and also of some others carrying the main outfall sewer under a sea channel; these proved to be in such good condition that the city surveyor had no hesitation in adopting similar pipes for this main.

They are 4-ft. diameter welded-steel pipes, 3/8 in. thick, with spigot and faucet joints. The material is in accordance with the British Standard Specification, and has a tensile strength of not less than 24 tons nor more than 30 tons per square inch, with an elongation of not less than 22 per cent. on a test bar 6 in. long. The pipes were raised to a temperature of 300 deg. to 350 deg. Fahr., and then dipped in a bath of Dr. Angus Smith's bituminous compound kept at a temperature 300 deg. Fahr. during the operation, after which they were covered with a wrapping of asphalted jute. They were then weighed, and the weight painted in white lead on the inside of the socket. When laid, the joints were caulked with gasken and 2½ in. of lead wool.

One decided advantage in the use of these pipes is the smaller number of joints to be made in bad ground, and the reduction of the volume of underground water which can enter such a pipe.

The amount of subsoil water which finds its way into trunk sewers, notwithstanding all attempts to make them impervious, is very large. Careful investigation in Boston proved that in pipes from 8-in to 36-in. diameter at least 40,000 gallons per mile per day got into the sewer, and it is estimated that on the average of large trunk sewers, 75,000 gallons per mile per day had to be provided for. These figures have, I believe, been adopted in the reports of the New York Sewage Commission. In waterlogged ground the figures would doubtless be greater.

On the other side of the harbor the subsoil is of an entirely different nature; sand is found in the lower portions, and red clay a little higher up. In the sand the tide rises and falls, evidently following some of the old channels of prehistoric days.

Some years ago, when a 5-ft. diameter sewer was being laid in a street 60 ft. wide, the trench was close-sheeted, and every precaution taken, as the contractor thought, to exclude water; yet he found it almost impossible to keep the trench dry enough to get in the concrete foundation, and claimed 50s. a lineal yard for an extra 6-in depth of excavation and concrete. (He was allowed 9s.)

An examination of an old survey of 1791, which lately came into the author's possession, shows that the site was at that date under the sea, and from other sources it is now discovered that the site was reclaimed about 1833.

Extensions of this sewer several miles in length were made through good ground, but one branch (about 1 mile), along what at one time was the margin of the lough, was nearly all the way through running sand. The contractor, however, put on very powerful pumps, and was able to keep the water out of the trench a sufficient time to enable the lower part to be built. Cracks appeared in buildings about ½ mile from the site; fortunately for him, his pumping operations were not suspected.

A relief sewer parallel to the main one referred to is now being constructed about 300 yds nearer the sea; although the ground is not good much of it being infilling the difficulty of construction is much less than in the case of the original sewer.

LOST PRESSURE IN GASEOUS EXPLOSIONS.

The following item has been abstracted from a paper read before the British Association for the Advancement of Science by Professor W. M. Thornton, D.Sc.,D., Eng:

When the maximum pressure of an explosion is calculated from the heat of combustion of the elements of the gaseous mixture, values are obtained which are in all cases about twice those found by experiment. The mean of a large number of "efficiencies of explosion" for different combustible gases approaches one-half. To account for this, four chief suggestions have been made: (1) That there is dissociation of the products of combustion; (2) that the specific heats are much higher at explosion temperatures; (3) that the products are rapidly cooled by radiation to the walls of the vessel; (4) that the combustion is not complete at the time of reaching the maximum pressure. None of these is in itself sufficient to account for all the loss of pressure. The suggestion is now made that it may be caused by the forces of cohesion which come suddenly into play at the moment of formation of a molecule, check the translational energy to which alone pressure and temperature are due, and raise for the moment the rotational energy of the combining bodies. It is shown that the ratio of the translational energy of two colliding and cohering bodies before and after collision is one-half, and this ratio is to be expected for the whole mixture.

The suggestion receives support from the form of the curve connecting efficiency of explosion and changed percentage of gas in the mixture. This efficiency can be shown to have the form $\mu = 1 - BN$, where B is a constant and N is the number of combustible units in unit volume. A combustible unit is defined as that group of one molecule of combustible gas and of oxygen atoms just sufficient for its complete combustion. At the upper limit N is zero, and the efficiency curve is triangular on a base coinciding with the limits of inflammability. Its mean height is therefore one-half of the maximum, and this agrees very fairly well with the observed values given by Clerk in the case of coal gas.

REFUSE DESTRUCTION.

By R. O. Wynne-Roberts,
Consulting Engineer, Regina, Sask.

[NOTE.—This very interesting paper was prepared by the author for presentation at the Convention of the Canadian Public Health Association, to have been held in Fort William two weeks ago, but which was cancelled owing to the European strife.—EDITOR].

ONE of the primary duties of a municipal authority is to dispose of the waste products of a city, quickly, hygienically and economically. Such duty, however, is a somewhat difficult one to carry out, sometimes. The satisfactory disposal of sewage, for example, has engaged the attention of specialists for many years, and it must be acknowledged that in a great number of places the efforts to efficiently treat sewage have more or less been failures, for a satisfactory effluent is to be found in only a few places. Yet, a solution must and will be found for this problem, and meanwhile communities are perforce to adopt the best available process.

In the matter of refuse disposal, the situation is somewhat dissimilar, for a large number of towns have surmounted the difficulties with good results.

The temptation is to dispose of the refuse by the easiest, even if it is not the most sanitary, means. Refuse tips are plentiful, but the modern tendency is to abolish such dumping grounds as are used without discrimination, and adopt some other method. It is somewhat late in the day of advanced sanitation for filth to be deposited on the outskirts of a city without care or consideration and thereby be an annoyance to the people who are dwelling in the neighborhood, if not create a menace to the public health.

Town refuse consists of such a heterogeneous mixture, it varies in every load, every day and in every place. In cooler climes there is a larger proportion of ashes, whilst in warmer latitudes vegetables and other refuse will be more pronounced. Refuse from towns in districts of high rainfall and humidity will probably be more moist and resistent to fire than in districts of low rainfall and humidity, in spite of the receptacles being usually covered.

The quantity of refuse produced per capita in Europe is less than in America and as a rule no division is made for the purpose of collection.

In America, town refuse is often divided into three main classes: garbage, which "consists of organic waste or residue of animal, fruit or vegetable matter, and any matter or substance used in the preparation, cooking, dealing or storage of meat, fowls, fruit or vegetables"; ashes, which "constitute waste due to the combustion of coal or other combustible material, from residences, manufactories or business places and consists of fine ash, clinker and unburned coal"; rubbish, which consists of discarded and useless waste matters from residences or places of business not classified as garbage or ashes, such as paper, straw, excelsior, rags, bottles, old clothes, shoes, tin cans and other like waste materials."[1] There are other refuse such as manure, street sweepings, dead animals, night soil, sludge, etc.

In America, the collection of town refuse is often made separately for each class named. Separate receptacles have to be provided and the contractors or the municipal authority make periodical calls to remove each class of refuse. Much depends upon the frequency of such collections, as to the cost of the work and the efficacy of this system. Daily removal by municipal forces will obviate practically all nuisance, and if rightly organized a combined collection can be as economically done, if not more so, than insisting on the wrapping of garbage in paper and the separate collection at less frequent intervals. It can be easily understood that the separation of garbage, ashes and rubbish entails the loyal support of the householders and the ordinary experience is that the simpler the duties imposed upon the householders and others, the more likely they are to be performed.

The common method of refuse disposal is by dumping it into depressions or pits or on waste land. Reference has already been made to this and it is therefore necessary only to state that progressive authorities are becoming more insistent that such a method is not desirable in well-goverened cities, unless due care is taken to cover the refuse with earth or other deodorant.

The disposal of garbage on pig farms is repugnant to the minds of all citizens having a high regard for the welfare of the people, and for the production of food by clean methods. It is stated that about 75 pigs are necessary to dispose of one ton of garbage daily.[2]

In Los Angeles, Cal., the garbage piggery was investigated by the Grand Jury. They reported that "the investigation of this Grand Jury shows that at the present time (March, 1912) there are located on the hog-ranch about 21,000 head of hogs; that the percentage of death of the hogs ranges from 40 to 65. We find, further, that the percentage of tubercular hogs on this ranch ranges from 10 to 20. Of this number two per cent. are condemned by the health officials, the other portion being placed on the market. We further find that cholera, strike, swine plague or swine fever is prevalent at the ranch at all times. In fact we find that at the present time this hog-ranch is quarantined for all purposes except for the purpose of slaughtering for food."[2]

It is palpably unnecessary to add to the foregoing indictment. The writer is unaware if this practice prevails in Canada.

It may be stated that a contractor has recently been awarded the contract for the disposal of the garbage of Los Angeles by means of a garbage reduction plant. The city is to receive 51 cents per ton for the garbage.[3]

Two cities in the United States own garbage reduction plants, namely, Columbus and Cleveland, Ohio. There are other cities where contractors have erected reduction plants to deal with the garbage of these cities.

This method was first introduced in Germany (where, curiously, it is not much used to-day) and later on it was introduced into the United States. It is similar to the plants installed in packing houses to dispose of the offal and to convert it into saleable by-products. Some of the reduction plants are operated on the "drying method," but the "cooking method" is stated to be the most satisfactory. The process consists of placing the garbage in steel digestor tanks, and when about 10 tons are so disposed of, the valves are closed and steam is admitted. After a few hours' cooking, the mixture is pressed to extract the free grease and the moisture. The solid matter is then dried and afterwards saturated with naphtha, gasoline or other solvents to dissolve the remaining grease. The solvent is recovered by distillation and the grease and tankage is sold to buyers, who refine the

[1] Report of the City Waste Commission of Chicago, 1914.

[2] Refuse Disposal in Small Cities and Towns, by Samuel A. Greeley, Illinois Society of Civil Engineers, 1913.

[3] Journal of Cleveland Engineering Society, March, 1914.

grease for various purposes, and the tankage is used for fertilizers.

Columbus is a city of about 185,000 inhabitants and the reduction plant has cost about $220,000. The sale of the grease and tankage brings more revenue than is sufficient to pay the cost of operation, plus the capital charges, as will be seel below:

Financial Statement for 1913.

1,095,594 lbs. of grease sold	$40,839.35
2,095 tons of tankage sold	14,223.31
Hides	1,247.39
Miscellaneous	489.73
Total receipts	$56,799.78
Total operating expenses	$39,560.25
Gross profit	$17,239.53
Allowing 4 per cent. interest and 20-year sinking fund	$16,292.00
Net profit	$ 947.53

The total quantity of garbage received was 20,710.74 tons, so the net profit amounted to about 4.57 cents per ton.

Garbage, however, is only one portion of town refuse and incidentally it may be mentioned that the householders in this large city, have to dispose of their refuse, other than garbage, by arranging with any one of the 140 private contractors.[4]

Columbus is now installing a Sterling destructor to cremate rubbish only. Natural gas is available and consequently the proportion of ashes is stated to be small.

Garbage reduction plants are capable of being operated with profit in cities of over 100,000 inhabitants. Mr. C. O. Bartlett, however, expresses the opinion that any small place producing one ton of garbage per day can be successfully treated in this manner.[3]

A full description of the reduction plant erected at Boston for the Boston Development and Sanitary Company, is to be found in the "Engineering Record" of May 10th, 1913, and of the Columbus plant in Mr. Irwin S. Osborn's report of January 1st, 1913, to which those interested in this process are referred for further particulars.

A number of towns in Britain have adopted the Lightning Dust Manipulator, for instance, Southwark, a large borough in London, Halfax, Hove and others. The process consists in pulverizing the raw refuse into manure. This is done by means of high-speed revolving hammers striking the refuse against the breaking block and a final disintegration effected by trituration between the hammers and the grinding plate. Southwark sells about 20,000 tons of manure annually. The manure is similar to black mold, and as the Southwark works are located in a populous part of London, and the plant has recently been extended, the process is practically inoffensive. Hove is one of the fashionable seaside resorts in South England and Halifax is a large commercial centre in Yorkshire.

The text of this paper is Refuse Destruction, and the remainder of the writer's observation will be confined to it.

For the sake of a clearer definition, furnaces operated at a temperature of about 1,500 degrees Fahr. or less, will be called incinerators, and those which have a working temperature of over 1,500 degrees will be called destructors. In America these furnaces are called low and high temperature incinerators respectively. It seems preferable to know what is referred to by a distinctive name, rather than by a qualifying term which is often omitted.

Fire is the oldest and best-known method of disposing of offensive rubbish. It has been adopted by all races and in all ages, with more or less satisfaction. Burying offensive matter is another ancient and effective way of getting rid of such matter.

The first engineer who successfully designed a furnace to effectually destroy town refuse by fire was Mr. Alfred Fryer, of Nottingham, England. This was in 1874. He built two such furnaces in Manchester in 1876 and these have been extended and improved and are still in use, which fact at least suggests that Fryer had evolved a scheme based on right principles.

This innovation, however, met with a hostile reception. The public prejudices against the adoption of such furnaces were so strong that it is surprising it survived.

Following Fryer, there were several aspirants who claimed to have designed furnaces superior to Fryer's, for example, Pickard's "Gommand," Wilkinson, of Birmingham; Healy, of Brighouse; Heard, of Paddington; Burton, of London; Stafford and Pearson, and others, but Fryer's furnace held its position. These, and some which were designed later on, were of the incinerator class—low temperature, slow burning, producing soft clinker and obnoxious gases. Mr. Charles Jones (Ealing) in 1885 introduced his "fume cremator" which was an ample proof that something was needed to improve the combustion.

Mr. William Horsfall, in 1887, brought out the first high temperature furnace, which improvement gave a new impetus to the process. Horsfall also improved the furnace by arranging for a front exhaust of gases, by which means all gases had to pass over the active grate before being discharged and by so doing the fume cremator was found to be unnecessary and was ultimately abandoned.

From 1887 to the present time many improvements have been introduced, such as steam jet blowers, forced air draft, regenerators or air pre-heaters, continuous grates, twin grates, mechanical feeders and clinkering, dust catchers, steam producers, and so on. To deal with each of these would entail a long paper, as each maker has devised certain features in connection with furnaces, etc. They will, therefore, be referred to collectively as far as possible.

Incinerators, then, are the survivors of the earliest types and destructors are the later developments.

Incinerators are furnaces capable only of slow combustion and require some form of drying-hearth or device for reducing the moisture contained in the refuse, prepatory to creation. Some incinerators are charged with large quantities of refuse at one operation, the result being the lowering of the temperature of the furnace, the prolonging of the period of cremation as the combustion is more often local than general, the passage of green gases and the production of soft clinker and little steam. An analyses of the gases and a record of the maximum and minimum temperatures in incinerators will doubtless show that the work done is not altogether satisfactory.

Experience has shown that with destructors the same as with other furnaces, the percentage of carbon dioxide, oxygen and carbon monoxide contained in the gases in the main flues, is in proportion to the completeness of the combustion of the fuel and the carefulness of firing and clinkering.

It is manifest that not even the best coal-fired furnace can produce satisfactory percentages of the above con-

[4] Report on Disposal of Refuse, Newark, N.J., 1912.

stituent gases of combustion unless the temperature of the furnace is uniformly maintained, the range of heat fluctuations kept as small as possible, the quantity of primary and secondary air supplied is controlled to satisfy as nearly as practicable the requirements of the fuel used, and that the fuel is charged in small and regular quantities. Although coal is not usually quite constant in its calorific quality, it is vastly more so than town refuse, and if care is needed in the case of coal-fired furnaces, it is reasonable to advocate somewhat similar care in the cremation of refuse, if scientific and sanitary results are to be achieved.

Many incinerators require coal or other fuel to assist in the combustion of refuse, although the proportion of combustible matter in such refuse approximates that contained in refuse in other places where, with destructors, no other fuel is required or used, and good clinker and power are produced.

Engineers have during the last century developed the design of coal furnaces for steam raising and countless other purposes. Different grades of coal require different types of grates, etc. It would not be expected that a grate designed to burn steam coal with the maximum of efficiency would produce good results if bark was consumed.

A prudent manufacturer who requires a furnace for any ordinary industrial purpose would ordinarily adopt one that has already proven efficient, and if for any special purpose which needed some experimentation, he would start where others had left off, (unless he had good reasons for doing otherwise) and so make use of whatever knowledge that was available.

Bearing in mind what has been achieved in many parts of the world with destructors, it would seem inadvisable to erect incinerators.

The more municipal engineers investigate this important problem, the more readily they will appreciate the necessity for the fullest consideration of the capabilities of various types of furnaces which it is contemplated to install.

There are several makers of destructors and incinerators on the market, and the writer does not propose to exploit any particular one. Each maker claims to have some features of superiority over others and doubtless some do possess certain advantageous qualities.

The original furnaces were top-fed and some are now being built on this plan, but in course of the last ten years or so back feed and front feed arrangements are found to answer rather better. Top feeding allows of mechanical labor-saving devices being used, but even then it entails more arduous labor to the men below in raking in the material by long rakes over the fires. Back feeding was introduced in 1891 and is claimed to be under better control, whilst front feeding means a better concentration of labor. Conditions will vary in different places and these must be taken into account when deciding the method of feeding.

Destructor furnaces require a strong draft in addition to the normal pull of the chimney, although, as one writer stated, since it has been demonstrated that incandescence can be maintained apart from the use of fans and regenerators, the question to be considered is whether it is good practice to run machines which absorb up to 15 per cent. of the total steam produced.[5] The steam jet is a simple, effective and economical blower, and the fan, being entirely mechanical, is more subject to wear and tear and liable to breakdowns and therefore should be in duplicate. The furnace pressure should be in balance, that is, the force of the blast under the furnace should be slightly in excess of the draw of the chimney, so as to render the intake of air at the doors during the time charging or clinkering takes place, as nearly nil as possible. The aim, nevertheless, of the furnacemen is to have these doors opened as few times as possible.

The advantage of either forms of blast does not appear to be very pronounced and to provide for all contingencies, the makers now usually include both in recent installations.

Pre-heating of the primary air is claimed to be of considerable value. The air, after being pre-heated, absorbs the moisture in the refuse most readily, and this is found to be done sufficiently quickly that refuse can be cremated without the intervention of a drying hearth. In ordinary steam boiler practice, pre-heated air is found to be of much value, for it increases the amount of water evaporated per hour. Brislee[6] gives an example of the advantage of pre-heated air. Two boilers were tested with the following results:

	Number one boiler. Cold air.	Hot air.
Weight of water evaporated, in pounds of water per hour	22,910	40,966
	Number two boiler. Cold air.	**Hot air.**
Weight of water evaporated, in pounds of water per hour	15,800	24,600

The increased evaporation was due to the extra heat brought into the furnace and the increased rate of combustion of fuel due to it.

In the case of the boiler No. 1 the evaporation was increased 79 per cent. and the No. 2 55.4 per cent.

Brislee points out that if air is heated before combustion is allowed to take place, then the heat in the air is added to the heat of combustion, and the quantity of heat available for raising the temperature of the products is therefore greater. In other words, conditions being equal in other respects, the pre-heating of air means economy of coal and the increased output of the boiler.

In destructors, however, regenerators do not constitute the only method of pre-heating of air. Regenerators consist of stacks of pipes, through which the hot gases pass out on their way to the chimney and around which the cold air passes into the furnaces. The sensible heat of the hot gases is partially imparted to the cold air and in this way the temperature of the air is increased from 200 to 300 degrees, or often more. This, of course, means the conservation of heat which would otherwise be lost in the chimney. Such regenerators offer some obstruction to the outgoing gases and to the incoming air, and to overcome this it is necessary to absorb some energy in driving fans. About 5 to 10 per cent. of the total steam produced from the refuse is thus utilized. Regenerators have in some instances been taken out for different reasons. It is easy to arrange for the primary air to be heated by passing it through flues built in the walls of the furnaces. This is being done in gasworks practice and has been found to be very effective. Indeed, such method of pre-heating air or an adaptation of the idea is provided in some destructors. Incidentally, the air required for the furnaces is taken from the vicinity of the refuse and by this means the building is ventilated.

[5] Surveyor, January 31st, 1913.

[6] Brislee. Introduction to Study of Fuel, 1912.

Continuous grates in one chamber are supplanting individual cells and grates and the advantage is evident. In the case of individual or single cells when refuse is charged into the furnace it has the tendency of lowering the temperature of that cell, and the effectual mixture and burning of the gases must take place in the combustion chamber. Whereas, in the case of the continuous grates, two or more grates are built side by side in one chamber with independent ash-pits beneath. When any refuse is charged onto any one of these grates, the cooled gases therefrom are mingled and burned in the furnace itself and no gree gases can escape into the combustion chamber without first passing over an incandescent body. Meldrum's Simplex Destructor was the first constructed on this principle and its usefulness was appreciated by other makers. Heenan and Froude, Horsfall, Fryer, Dawson and Manfield and other destructor builders now design some form of continuous, twin or series grates.

Mechanical stoking and clinkering and other forms of labor-saving devices are installed in a number of destructors. Boulnois and Brodie's charging trucks, Marten's charging apparatus, Horsfall's tub feed, Heenan and Froude's hydraulic feeder and others are examples of the methods most in use. Heenan and Froude's trough grate and hydraulic ram clinkering machine and Sterling's clinkering grate are installed in many plants. According to Mr. Fetherston's report[7] the arduous work of charging and clinkering at the Clifton (New York) destructor has been reduced by the use of the hydraulic ram charger and clinkerer and trough grate. The following figures are extracted from his report:

Comparison of Work Elements.—Official Tests.

Plant. Both in New York.	Cost per ton supervision and labor.	Pounds burned per furnace man per hour.	Pounds burned per sq. ft. per hour.	Per cent. of time furnace door open.
West New Brighton, 1908	$0.76	1,357	54.3	73.7
Clifton, 1913	0.41	3,330	144.2	5.1

Mr. Fetherston, however, expresses his opinion that some time must elapse before the complete economy of the mechanical devices is demonstrated.

Conveyors have been tried in several installations, but owing to the heterogeneous character of the refuse, they have not always been found to answer. The same remark applies to refuse elevators, etc. The three buckets and rake elevators in use at the Hackney destructor (London, England) capable of raising 10 to 12 tons per hour, are found to be very expensive to maintain and are liable to serious breakdowns.[8]

Hoppers or storage bins above the destructor furnaces are often found to be unsatisfactory, owing to the tendency of the refuse to bind and arch over the opening, and the bulky nature of the refuse often renders the hoppers inadequate in capacity, in which case some city authorities store the refuse in the carts or wagons and thus obviate creating of nuisance. In some cases the refuse in bins tends to ignite and cause an emission of noxious gases. In recently built destructors the hoppers are located behind or in front of the furnaces and are sufficiently large to hold one or more day's supply. Such a position is both cool and handy for hand-firing.

In the more recent developments of destructors the authorities have observed that it was possible to derive considerable steam power. The ordinary steam-producing capacity of destructors is calculated at one pound of steam for each pound of refuse burned, and as one horse-power may be based on 30 pounds of steam per hour, it will be seen that one ton (2,000 pounds) will, on the above basis, produce 67 horse-power, but a large quantity of steam is required for the plant itself, so that the net quantity of steam available for other purposes is less.

There are plenty of instances where the production of steam has exceeded one pound per pound of refuse.

Official tests made at the Clifton destructor in 1913 with a winter mixture of refuse gave a gross equivalent evaporation from and at 212 deg. Fahr. of 1.00 to 1.11 pounds at a pressure ranging from 117 to 126 lbs. per square inch, but at the West New Brighton destructor the results were 1.10 to 1.41 pounds of steam at a pressure of 130 to 137 lbs. per square inch. The production of steam during the year 1911 was 1.23 pounds per pound of refuse.[7]

In Milwaukee, the evaporation was 1.34 to 1.45 pounds and at Westmount, P.Q., from 1.48 to 2.11 pounds.[4] In Calgary, Alta., the average evaporation at tests was 1.13 pounds. In Darwen (England) the average evaporation during the year was 1.23 pounds, whilst on a test when burning unscreened refuse and slaughter-house refuse was 1.55 pounds of steam from and at 212 deg. Fahr. In Huddersfield (England) with one part of sewage sludge and two parts of refuse 1.4 pounds of steam were obtained.

A test was made in Rochdale (England) for the purpose of comparison. By using ordinary coal slack having a calorific value of about 12,500 B.t.u. 7.33 pounds of steam were produced from and at 212 deg. Fahr., as compared with 1.97 pounds from refuse.[9]

At Montgomery (Ala.) in 1911 the following test results were secured: 1.37 pounds of steam per pound of refuse; carbon dioxide in the waste gases, 11 per cent.; temperature in combustion chamber, 1,920 deg. Fahr. The refuse consisted of 25 per cent. ashes, 42 per cent. garbage, 13 per cent. rubbish, and 20 per cent. manure.

The steam produced by burning refuse is utilized for a variety of purposes, such as pumping sewage, or water, generating electricity, etc.

Part of the steam generated from refuse in London, Ont., is used for heating the Victoria Hospital, which is situated fifty feet away. In one city 72 million foot-pounds of energy is derived from every ton of refuse and used for pumping sewage. In Liverpool and Rotterdam, for example, the electric energy generated is used for street railway operation. In West New Brighton and Clifton plants, already referred to, a large quantity of steam is not utilized owing to the fact that the New York City charter prohibits its sale and consequently no revenue can be derived in this manner. This represents a loss of about $7,500 per annum. The quantity of refuse burned at each of these places is about 9,500 tons per year. In Westmount, P.Q., the destructor is an auxiliary enterprise operated in the same building as the municipal electric lighting plant, the steam generated by the cremation of the refuse being used in the production of electrical energy. Messrs. Hallock and Runyon, the engineers who were appointed to report on the disposal of refuse by the City of Newark,[4] stated that the total revenue in 1910 for electric lighting and destructor plants was $102,149.17, and the total cost of operation of the combined plant was $75,426.38, leaving a net profit of $26,722.79. The operating costs include all capital

[7] J. T. Fetherston, New York, February, 1914.
[8] Journal of Institution of Municipal and County Engineers, July, 1914.

[9] Refuse Disposal and Power Production, Goodrich.

charges and depreciation. The cost to the Health Department for the refuse destroyed was $9,449.06 for the year. The population of Westmount is about 16,000.

Other examples could be cited but the paper is already longer than was anticipated.

One incidental result of good steam production is the production of good clinker, which can be used for many purposes. Low temperature cremation results in soft clinker which is not only useless but objectionable, as it cannot be used and it often contains partially consumed organic matter. Clinker should be well fused and vitrified and this can only be produced by maintaining an uniformly high temperature in the furnace.

Good clinker is used for making pavement slabs, for sewage filtering media, brickmaking, crushed into sand and mixed with lime for mortar, etc.

Reference has already been made to steam production. In the earlier plants, the boilers were placed in the furnace directly over the fire, but it was found that the cooling effects of such boiler militated against the successful cremation of the refuse. The next step was to place the boiler between two cells and, although better results were obtained, the makers in later installations have located the boilers beyond the combustion chamber. By this means the maximum temperature is secured and the gases adequately combusted before coming into contact with any cooling surfaces. The figures quoted point to the possibility of developing considerable power by the high temperature cremation of refuse. If due attention is paid to the fundamental requisites of a destructor the cost of operating the same can be materially reduced by the sale or utilization of the steam and hard vitrified clinker produced.

In conclusion, the author has observed that some disappointment has, in places, been experienced owing to the makers' claims being exaggerated and impossible of realization. It would, of course, be folly to decry every new device, arrangement or design, until it has been put to a practical test, for that would be tantamount to placing an embargo on all legitimate developments, but experiments are costly and occasionally disturbing, as was recently found to be the case in a large plant in North America, whose designers received due publicity in engineering journals. The achievements that were going to be accomplished fell short and the works are now being improved.

The evolution of the destructor has been slow and expensive and the results of experience in all parts of the world has greatly assisted the makers in deciding upon the arrangements, capacity and construction best suited for the refuse produced in different places in different climes.

New York, Westmount or other destructors in the the east may not be quite suitable for western refuse, and doubtless this is the case. Each city has its own problem to solve and it, therefore, behooves that the authority contemplating the installation of a destructor or incinerator should take the fullest possible advantage of the experience of others under similar conditions and of the plant best suited to satisfy its own specific needs.

A Government wireless station will shortly be opened on Valentia Island, on the southwest coast of Ireland. It has been constructed by the wireless department of the Post Office, the installation being supplied by the Marconi Company. With a range of 500 miles, it is chiefly destined to keep Atlantic liners in touch with land two hours longer than is possible at present with the Crookhaven station.

THIRTY-THIRD CONVENTION, AMERICAN ELECTRIC RAILWAY ASSOCIATION.

The program for the 33rd Annual Convention of the American Electric Railway Association to be held at Atlantic City October 12th to 16th has been announced. The American Association proper and its four allied associations—Engineering, Accountants, Claims, and Transportation and Traffic—all hold sessions during the time of the convention. The programs are very elaborate. Over 73 committees are to report and papers are to be read on some very important subjects. The speakers before the American Association include Hon. Frank W. Stevens, former Chairman of the New York Second District, Public Service Commission; H. C. Donecker, Assistant General Manager, Public Service Railway Company, Newark, N.J.; Calvert Townley, Chairman of the Board of Directors, Lackawanna and Wyoming Valley Rapid Transit Company; Harry A. Bullock, Secretary, New York Municipal Railway Corporation, and R. B. Steams, Vice-President, The Milwaukee Electric Railway and Light Company.

Among the important reports to be made is one from the Committee on Public Relations, presenting a "Platform of Principles" covering what the committee believes to be the fundamentals of a lasting and proper adjustment of relations between the railways and the public.

The Accountants' Association is to consider the new classification of accounts which was prepared by the Interstate Commerce Commission in connection with one of the committees of the association, and will pass on a plan for an educational course for the accounting employees of electric railways. John R. Wildman, Professor of Accounting, New York University, H. S. Swift, treasurer, West Penn. Traction Company, J. F. Fogarty, secretary, North American Company, A. T. Smith, assistant chief, Division of Valuation, Interstate Commerce Commission, and Robert Sealey, North American Company, will deliver addresses.

The Engineering Association has a very large number of important matters to come before it, including the reports of its standing committees.

To the Claims' Association will be presented the report of its committee having in charge the formation of an accident prevention board, which it is intended will conduct a campaign for the prevention of accidents among the electric railways of the country.

Among the speakers before the Transportation and Traffic Association is N. W. Bolen, General Superintendent, Public Service Railway Company, Newark, N.J., who will talk on the Organization of a Transportation Department. This association will consider among other things a report of the committee dealing with the question of motor buses as auxiliary for electric railways.

The report of the Joint Committee on the Joint Use of Poles, made up of representatives from the American Electric Railway Association, National Electric Light Association, the American Institute of Electrical Engineers and the American Telephone and Telegraph Company will be considered by the American Association.

This committee has now been at work for two years in the preparation of a form of agreement and specifications covering the joint use of poles and the adoption of its report, it is believed, will mean much in the clearing up of obstructions in the streets of the cities of the country.

GUTTER CONSTRUCTION FOR STREETS AND ROADS.*

By T. Hugh Boorman, C.E.

HIGHWAY engineers and road specialists have always agreed that the pre-requisite for a good pavement is proper drainage and a substantial foundation for the wearing surface, and it is now generally conceded that we must have a waterproof surfacing even for country roads.

On a building's roof, we must pay the greatest attention to the gutter and afford the best method possible for the carrying off of the rain water to the outlets as efficiently and speedily as possible. Given the fact that we are to roof our roads with waterproofing material, does it not follow that we should apply similar precautions for road roofs?

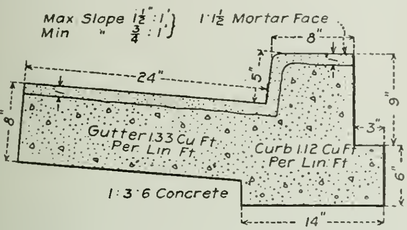


Fig. 1.—Standard Type of Combined Curb and Gutter.

In the June 10, 1914, issue of "Engineering and Contracting" is given the construction of concrete curb and gutter as adopted in Washington by the District Commissioners, under the supervision of Captain Mark Brooke, Engineer Corps, U.S.A.:

"**Concrete Curb and Gutter.**—In Fig. 1 is shown the standard type of combined curb and gutter in general use. It will be noted that the curb is unusually thick and the base therefor is quite broad. The method employed in laying is as follows:

"A trench is excavated and trimmed to a depth of at least 14 inches and a bed of bank gravel, free from excess clay or loam, spread to a depth of 6 inches and rammed. In making the curb, forms are placed and the mortar face formed by plastering on the inside before the curb concrete is laid. Curb and gutter is divided in 10-foot lengths, a clean cut joint being made either by use of a thin metal plate or with heavy paper. The face forms on the curb are removed within 24 hours and the surface troweled to a neat finish.

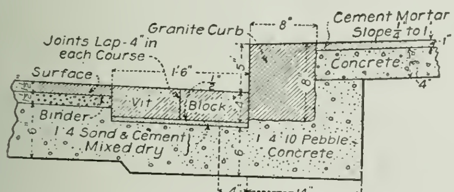


Fig. 2.—Granite Curb and Vitrified Brick Gutter.

"The specifications call for a high quality of sand and no stone over 2 inches in diameter. The mortar surface on gutters is placed immediately after laying concrete and thoroughly manipulated by troweling and beating with wooden battens so as to break any air cells and make the surfacing solid. Joints are filled with sand. A coating of dry cement and fine sand, 1:1 mix, containing thoroughly incorporated coloring matter, is floated on the surface. A jointing tool is used, cutting to a depth of ½ inch, and the exposed surface covered with sand for protection.

"**Granite Curb and Brick Gutters.**—The granite curb and vitrified block gutter is shown in Fig. 2. Granite curb is set in the following manner:

"A trench is excavated 18 inches wide and 15 inches below the top of the curb when set. One edge of this trench is 4 inches beyond the finished curb line toward the centre of the street. Five inches of 1:4:10 pebble concrete is placed in this trench and the curb set immediately, heavy mauls being used to bed it firmly. As soon as the curb is laid the trench on the sidewalk side is filled to within 5 inches of the top of the curb with concrete tamped in place. Excess concrete in front of the curb which will interfere with laying vitrified block gutters is removed and earth filled in behind the curb to prevent too rapid drying out of the concrete. No provision is made for longitudinal joints between the curb and the street surface base.

"In laying the gutter as soon as practicable after the concrete base has been laid, a dry mixture of sand and cement is spread to a thickness of not less than ½ inch as a bed for the paving blocks. The blocks are laid on edge joints, being broken so that each block has at least a 4-inch lap in every course. A plank is laid over several courses and a rammer used until the blocks reach a firm bed and present a uniform surface. After ramming, the gutter is grouted with a thin, easy flowing grout of neat cement."

On examination of the concrete gutter on the Chevy Chase experimental road sections in Washington and Maryland last month, I found several cracks, and venture the opinion that a prepared asphalt joint applied across the work every 25 feet would obviate this trouble at a very trifling expense. The work referred to, however, is in connection with broad avenues and streets having no business traffic; and what I wish to emphasize is the fact that in our city streets particularly our construction of gutters is generally poor, from the fact that stone blocks are used transversely, instead of longitudinally.

In England the gutters are laid longitudinally generally in the case of stone or wood blocks, with the inner two lines depressed about half an inch, so forming a natural curved gutter.

I have seen asphalt blocks on roads at Irvington, N.Y., so laid, and on the approaches to the North Philadelphia Depot of the Pennsylvania Railroad brick has been set in this way; on one side of the depot twelve courses of brick and on the other eight courses.

I contend that in all cases where other than a monolithic sheet pavement is used, the gutter should be paved with blocks, longitudinally laid, and with a natural curve. While realizing that innumerable varying surfaces, requiring different construction of gutters, call for exceptional work, I am submitting the following suggestions for consideration:

When practicable, all avenues and broad thoroughfares, other than in business sections, should have a Portland cement concrete curb and gutter, preferably strengthened and made more thoroughly waterproof by the addition of some of the improved dry or liquid compounds.

*From a paper read before the American Society of Engineers, Architects and Constructors, July 4, 1914.

For country and suburban roads, where cobblestones are obtainable, they should be laid from two to three feet in width, and after being placed should have poured in the interstices hot pure asphalt. Asphalt should be used which is of the best grade, free from coal tar or any of its products, and which will not volatilize more than one-half of one per cent. under a temperature of 300 degrees Fahrenheit for ten hours. The asphalt should not flow under 212 degrees Fahrenheit and should not brittle at 15 degrees below freezing, Fahrenheit, when spread thin on glass. In all cases of brick, stone, or wood blocks laid longitudinally along the line of curb and with joints broken, said joints should invariably be filled with asphalt cement of quality above described.

MUNICIPAL DEVELOPMENTS AT ASSINIBOIA, MANITOBA.

In *The Canadian Engineer* for September 3rd a description was given of the water and sewerage systems recently installed at Deer Lodge, in Assiniboia, a western suburb of Winnipeg. Since its publication we have been favored with some additional information respecting municipal improvements that have been made during the past several years in that locality. In this time over $410,000 have been expended in the municipality of Assiniboia for water supply and sewerage systems, and similar work to the extent of $500,000 is contemplated and in the process of design. During the past two years, also, pavement and bridge work has amounted to $215,000, construction work at the present time amounting to $170,000. Mr. G. W. Rogers is engineer for the municipality.

DECEMBER MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

At its annual meeting in New York December 1 to 4, the American Society of Mechanical Engineers will have a session on engineering metals and their application to methods of manufacture. Steels for construction and for tools, cast-irons and alloys of copper, tin and aluminum will be particularly investigated, with a view to bringing out as a matter of common knowledge the advances that have been made in these fields up to the present time. The session will be in charge of the sub-committee on iron and steel. A number of papers will be presented.

Another session that will be most interesting is that devoted to the general subject of engineering in connection with civic administration and public service. Papers on municipal engineering and related matters will be presented, among which are noted: "Utilization of Municipal Wastes," by Irwin S. Osborn, consulting engineer to the Department of Street Cleaning, Toronto, and other cities; "Training of Municipal Employees," by H. M. Waite, city manager, Dayton, Ohio; "The Cleaning of Filter Sands," by Sanford E. Thompson, consulting engineer, Newton Highlands, Mass.; "Controlling Factors in Municipal Engineering," by M. L. Cooke, director, Department of Public Works, Philadelphia, Pa.; "The Cleaning of Public Buildings," by W. H. Ball, Chief of the Bureau of City Property, Philadelphia, Pa.; "Municipal Colleges in Germany," by C. L. King, University of Pennsylvania, etc.

The usual sessions on machine shop press, railroads, etc., will be held. The above are mentioned in particular as being of special interest to our readers.

WAR AND ENGINEERING TRADE ABROAD.

The following interesting item on the effect of the war on European engineering trade was published in "Mechanical World" of August 28:

Of the several countries engaged in the present European conflict, it is tolerably evident that Great Britain stands to lose less by trade dislocation than any other. It is true that some of our manufacturing industries have been badly hit, but so far as the engineering trade is concerned a despondent view of the situation is by no means justified. Makers of textile machinery will probably be the worst sufferers, as the continent represents their chief outlet. But as regards general engineering the outlook is much more satisfactory. Certain branches are of course busily employed in meeting the demands of the naval and military authorities, and in these we have every reason to expect a continued period of activity. Makers of structural iron and steel should benefit by the elimination of Belgian and German competition, while, if machine-tool makers find the principal European markets closed against them, they have ample compensation in the absence of German competitors in our large home market. A further advantage we possess over continental competitors is that we are in a position to meet the requirements of colonial and neutral markets now that the western trade routes are open; and hence the present situation provides us with a unique opportunity of consolidating our position in such markets and extending our influence where possible.

The view is held in many quarters that our present trouble may be a blessing in disguise, if it only affords opportunities for recovering some of the industries which we have allowed Germany to filch from us. It is suggested that the refining of lead and other of the baser metals should again find a deal of employment in this country. Again, the manufacture of carbon twist-drills, which has drifted largely into German hands, should be recoverable if suitable plant he installed. This latter proviso is of course almost always a condition of success, and although it requires a considerable amount of courage to expend money under the present circumstances, it is tolerably obvious that those who do so will not have long to wait for their reward once the war cloud shows signs of lifting. Meanwhile, wise economy is to be commended; but the indiscriminate curtailing of business-getting organization, advertising, etc., savors of a penny-wise and pound-foolish policy, the results of which are bound to be the reverse of beneficial.

The building permits for the town of Welland during the month of August this year amounted to $13,625, which shows a decided decrease upon the amount for 1913 of $38,100. The building permits for the year to the end of August, total $314,018; and in 1913, the total shown was $356,996.

The following account has been published relative to building permits issued during the last month in the town of Galt: total estimated cost of permits issued during August, 1914, $92,500; total estimated amount for August, 1913, $40,565, showing an increase of $51,935. The increase is due to the permit which has recently been issued for the construction of an armory at a cost of $80,000.

The Bridle Belt Railway and Navigation Company propose to construct a $50,000,000 terminal project at Seattle, Wash., the initial unit of which is to be undertaken at once at a cost of $15,000,000. This first unit calls for the construction of two docks, each 4 stories high and 200 x 800 ft. These docks will connect with an 8-story building over Railroad Avenue, 500 x 500 ft., which in turn will connect with a 20-story 250 x 500 ft. hotel and office building facing on First Avenue. The hotel and office building will have a total depth below the First Avenue level of 10 stories, the ground floor of which will open on Railroad Avenue.

SUBTERRANEAN WATER AND THE CONSTRUCTION OF A CORE-WALL FOR AN EARTH DAM.

A SUMMARY taken from a letter by Mr. Harrison Souder, published in Proceedings of the American Society of Civil Engineers (Vol. XL., page 1569), deals with the Hinckston Run dam, built 13 years ago near Johnstown, Pa., showing the methods and the results of the employment of grout injection to close underlying rock strata against seepage under the dam. Despite the age of the work, the account is of great interest, for it was not until recently that any matter upon this early use of grout injection was published. Mr. Souder's report, as given in *Engineering and Contracting*, June 10, 1914, is reproduced in the following paragraphs.

The original Hinckston Run project called for an earth dam, 60 ft. high, to retain some 400,000,000 gals. of water, with a depth of 45 ft. at the breast. The intention was to build a dam with a clay core, but, as an unlimited quantity of cinder from the steel plant was available, it was decided, after the work was started, to use this as backing for the dam, in place of earth, and eventually to fill the whole valley below with this material, thus rendering the structure practically unbreakable. In view of this and the additional expense incurred in making the cut-off tight, the proposed height of the dam was increased to 80 ft., and later to 85 ft., above the original creek level. This gave a total maximum height above the bottom of the core-wall ditch of 112.8 ft., a depth of water at the breast of 73½ ft., and a capacity of 1,100,000,000 gals. The lake thus formed is 1¼ miles long. The watershed above the dam is 10.75 square miles.

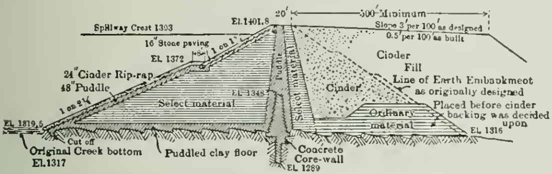


Fig. 1. Maximum Cross Section of Hinckston Run Dam.

The cross-section of the dam as built is shown by Fig. 1. The lower inner slope is 1 on 2¼, with 4 ft. of puddle and 24 ins. of cinder riprap. The slope above the berm is 1 on 1¾ with puddle lining diminishing to 2 ft. thick at the top. The facing is hand-laid stone paving. The puddle wall is 16 ft. thick at the top of the concrete core-wall, and diminishes to 4 ft. at the top of the dam.

When the core-wall ditch had been carried down to hard rock at what was thought to be the proper depth, some test holes were bored through the bottom to determine the character of the rock below. This disclosed a layer of hard sandstone a few feet down, with considerable water flowing below and above it. It was decided to deepen the ditch considerably, in order to get below any rock strata that might come to the surface within the flooded area, and to substitute a concrete core-wall for the clay one originally proposed.

An air compressor plant was installed. This was a 14 x 18-in. Ingersoll-Sergeant machine capable of driving two rock drills and six pneumatic rammers. These rammers were used in tamping concrete and also in puddling clay in such places as could not be covered by a 10-ton steam roller which was also supplied at this time in place of the 3-ton horse roller in use.

The finished ditch averaged in depth 25 ft. below the grubbed surface in the valley, but reached 50 ft. at the ends. The shale was excavated with picks, but the harder rock was loosened with light charges of dynamite, care being taken not to shatter the foundation or open up the seams. The advisability of cutting off the underflow to as great a depth as possible was realized, and it was determined to remove the shale down to the sandstone and try to cut off the flow below by forcing in cement grout under air pressure.

Grout Injection.—Drill holes, 2 ins. in diameter and from 10 to 16 ft. deep, were drilled through the rock, averaging about one hole per linear foot across the valley. Iron pipes, 2 ins. in diameter, 18 ins. long, and threaded on one end, were cemented into these holes. Portland cement grout was poured into them and then air at a pressure of from 30 to 60 lbs. was applied. The first holes were approximately 6 ft. apart. They were drilled generally 10 ft. below bed-rock.

Fig. 2 is a sketch of the first contrivance or receiver devised for applying the grout. It was a cylinder, 8 ins. in diameter and 6 ft. long. A screw flange was provided at top and bottom, and a steel head-plate was bolted to each end, with rubber gasket packing. The top bolt holes were open to allow quick removal of the lid. A 2-in. pipe with plug cocks was provided at the top and bottom. With a short hose, the cylinder was coupled to the pipes in the holes. The cylinder was filled with grout; the valve was opened; the grout ran into the drill holes; and the air pressure was then applied at the top. The contrivance was mounted on a truck running on a track in the bottom of the ditch. After trial it proved to be too slow and cumbersome, and another method was devised and operated satisfactorily. Fig. 3 is a sketch of this final arrangement. The method of grouting was as follows: A 1-in. pipe, long enough to reach to the bottom of the hole, was

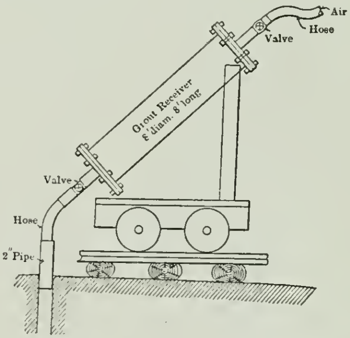


Fig. 2. Grouting Device Tried and Abandoned

inserted and air was applied to blow out water and dirt. Then a tee and the pipe, *C*, were attached to the tube in the drill hole with a sleeve union, as shown. The cock, *A*, was closed, the cock, *B*, was opened, and air was applied, thus forcing the water out of the hole and into the crevices and near-by drill holes; meanwhile, the pipe, *C*, was filled with grout, and the air hose was connected at the top. Then *B* was closed, *A* was opened, and air was gradually applied at the top of *C*, forcing the grout down into the crevices. The pipe was refilled about every 10 minutes until the hole would take no more. The apparatus was then removed and a cap was screwed on the

tube in the grouted hole. After a given length of ditch was grouted in this way, and sufficient time had elapsed to allow the grout to set, test holes were bored within the grouted area and the process was continued until there was no indication of water flow below the bottom. The greater part of the bottom was grouted successfully in this way, but, as explained later, the grouting scheme was abandoned where the core-wall ditch entered the side-hills.

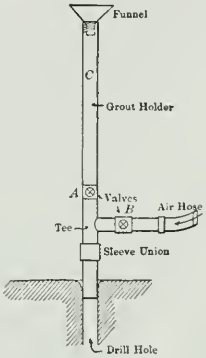


Fig. 3. Grouting Device Employed.

Handling Flow from Seams.—At the east end three large vertical open crevices were uncovered. The flow from these was so considerable that it was necessary to put in a force pump with a 4-in. suction and a 3-in. discharge, in order to keep the ditch clear. As the grouting method, after continued trials, did not give satisfaction at this end, it was decided to take up the bottom until the principal water strata were reached. This was done, and concrete was placed in the ditch, all the walls being plastered first with a rich cement mortar worked in with trowels. Two coats of plaster were applied on the north or reservoir side and one on the south side. The suction pipe of the pump was built in concrete, and carried up with the wall. The strong flow of water in this section of the ditch made it difficult to place the concrete for the core-wall without having the cement washed out before it set.

At first, the method indicated in the sketch, Fig. 4, was tried, namely, a line of 1-in. sheeting was placed as

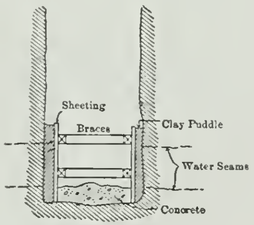


Fig. 4. First Method of Handling Water in Core-Wall Ditch.

shown, and clay was rammed between the sheeting and the rock to stop the water flow. Concrete was placed between the sheeting which was raised gradually as the concrete was carried up. This did not prove wholly satisfactory, and the method of piping the water directly to the sump was adopted, as shown in Fig. 5. This proved successful. Where there was too great a flow of water, plastering could not be done, but considerable neat cement was dumped in along the walls with the concrete and well worked in. After the concrete was well set, the pipes were plugged and the flow of water was shut off. As the concrete was carried up, the water came out of the ditch walls higher up, showing that the underflow had been intercepted. The core-wall ditch was extended well into the hills on each side of the valley, and test holes were bored for water, none being found because, after a certain distance, the rock became hard and massive and free from seams. At the west end of the ditch, there was as much trouble with water. It would seem that the underflow of the whole valley was concentrated at this point, the rest of the ditch having been grouted and the flow cut off.

The drill-hole grouting method failed in the west side of the valley, as in the east, and here the bottom was also taken out, down to the water strata, and the water fought inch by inch by piping it from the streams to the sump, as before described, and the ditch was completely filled with concrete.

The proportion for the concrete in the core-wall was 1 : 2 : 5, generally; but, at the bottom, it was much richer in cement, which was not spared in efforts to make a tight job. Near the crevices a proportion of 1 : 1 : 2½ was used. These proportions had to be varied, also, to suit the sizes of the stone supplied, which varied from ½ in. at times to 3 in. The top section of the wall was made of 1 : 3 : 6 and 1 : 3 : 7 cinder concrete. The concrete was mixed in a machine of the continuous-mixer type, consisting of a long square revolving box with a helix at the back. The

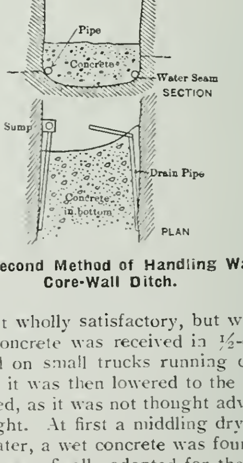


Fig. 5. Second Method of Handling Water in Core-Wall Ditch.

machine was not wholly satisfactory, but was the best to be had. The concrete was received in ½-cu. yd. dump buckets, carried on small trucks running on light track to the derricks; it was then lowered to the bottom of the ditch and dumped, as it was not thought advisable to drop it from any height. At first a middling dry concrete was required, but, later, a wet concrete was found to give the best results and was finally adopted for the remainder of the work.

After the core-wall reached above the surface the faces received two coats of plaster, one inside against the wood forms and another after the forms were removed. For the upper part of the wall, the plaster coat on the down-stream side was omitted; and, on the up-stream side, a cement wash applied with a brush was substituted for the second coat of plaster. Where sections of the wall joined, bonding grooves were provided.

The concrete core-wall contained 10,840 cu. yds. and required 13,166 bbls. of cement, or an average of 1.21 bbls. per cubic yard. The grouting and plastering took 2,078 bbls. of cement, in addition. The exact quantity of cement used in grout alone is not known.

SOME TUNNELING COSTS.

THE United States Bureau of Mines has made exhaustive investigation into the subject of mine tunneling, and, in the course of the work, found that data respecting tunneling costs were remarkably scarce. The Bureau thereupon undertook to gather the available data, which have been published in a recent bulletin from which the following statistics have been complied:—

LOS ANGELES AQUEDUCT.

Little Lake Division, Tunnels 1 to 10A.

Location: Inyo County, Cal.

Purpose: Water supply, power and irrigation.

Cross-section: Straight walls, arched roof, dished bottom.

Size: 7 feet 10 inches wide by 8 feet 5 inches wide.

Type of power: Electric power purchased at a nominal cost per kilowatt-hour from a hydraulic plant constructed and owned by the aqueduct.

Ventilators: Pressure blowers.

Size of ventilating pipe: 12 inches.

Drills: Pneumatic hammer, usually 2 in each heading.

Mounting of drills: Horizontal bar.

Number of holes per round: Usually 14 to 16.

Average depth of round: 6 to 10 feet.

Number of drillers and helpers per shift: 2 drillers and 2 helpers.

Number of drill shifts per day: Usually 1, but sometimes 2.

Explosive: 40 per cent. gelatine dynamite, with some 20 per cent. and some 60 per cent. Ammonia dynamite also tried.

Number of muckers per shift: Usually 5.

Number of mucking shifts per day: Usually 1, but 2 when 2 drill shifts were employed.

Type haulage: Tunnels 1 to 3-N, mules; tunnels 3-S, to 10A-N, electric; tunnel 10A-S, mules.

Wages: Drillers and helpers $3, muckers, $2.50, blacksmiths $4, helpers $2.50, motormen $2.75, dumpmen $2.50.

Tunnel 1B-S, Length 1,341 Feet.

(Through medium-hard granite at an average speed of 225 feet per month.)

	Cost per foot of tunnel.
Excavation	$ 9.15
Engineering	.18
Adit proportion	.28
Permanent equipment (estimated)	2.35
Timbering (857 feet)	1.02
	$12.98

In this tunnel, as in all of the tunnels of this division and of the Grapevine division, the cost of excavation includes the wages of shift foremen, drillers, helpers, muckers, motormen or mule drivers, dumpmen, blacksmiths and helpers, machinists, electricians (part), and power engineers; also the cost of powder, fuse caps, candles, light globes, machine oil, blacksmith supplies and fuel, and machinists' supplies, and the cost of power and of repairs for power, haulage, compressor, and ventilating machinery.

"Engineering" includes the cost of giving line and grade, etc.

"Adit proportion" is a proportionate charge per foot of tunnel to defray the cost of an adit from the surface to the tunnel line.

"Permanent equipment" costs were not segregated for each tunnel, but were compiled for the whole division, so the charge represents a proportionate charge per foot for the entire division cost, without salvage, of trolley and light lines, including freight and cost of installation; pressure air lines with freight and installation; ventilation lines with freight and installation; water lines with freight and installation; mine locomotives and cars, picks, shovels, drills and drill sharpeners, with repairs for the last four items.

Tunnel 2, Length 1,739 Feet.

(Through medium-hard but very wet granite at an average speed of 170 feet per month.)

	Cost per foot of tunnel.
Excavation	$ 8.81
Engineering	.19
Adit proportion	.34
Permanent equipment	2.35
Timbering (1,590 feet)	3.28
	$14.97

Tunnel 2-A, Length 1,322 Feet.

(Through medium-hard granite at an average speed of 150 feet per month.)

	Cost per foot of tunnel.
Excavation	$ 8.05
Engineering	.16
Adit proportion	.34
Permanent equipment	2.35
Timbering (1,322 feet)	2.51
	$13.41

Tunnel 3-N for 1,148 Feet.

(Through medium-hard granite at an average speed of 150 feet per month.)

	Cost per foot of tunnel.
Excavation	$10.10
Engineering	.23
Adit proportion	.51
Permanent equipment	2.35
Timbering (956 feet)	2.44
	$15.63

Tunnel 3-S for 1,358 Feet.

(Through granite of variable hardness and containing pockets of carbon-dioxide gas, at an average speed of 155 feet per month.)

	Cost per foot of tunnel.
Excavation	$12.38
Engineering	.28
Adit proportion	.16
Permanent equipment	2.35
Timbering (1,244 feet)	3.28
	$18.45

Tunnel 3, Length 4,044 Feet.

(Through decomposed granite of medium hardness, dissected by slips and talcose planes requiring timber where ground was wet, and also containing pockets of carbon-dioxide gas, making work difficult and requiring extra provisions for ventilation. Average speed, 140 feet per month.)

	Cost per foot of tunnel.
Excavation	$12.67
Engineering	.24
Adit proportion	.35
Permanent equipment	2.35
Timbering (3,570 feet)	2.71
	$18.32

Tunnel 4, Length 2,033 Feet.

(Through medium-hard to hard granite at an average speed of 145 feet per month.)

	Cost per foot of tunnel.
Excavation	$12.00
Engineering	.24
Adit proportion	.16
Permanent equipment	2.35
Timbering (1,705 feet)	2.16
	$17.01

Tunnel 5, Length 1,178 Feet.

(Through medium-hard to very hard granite at an average speed of 120 feet per month.)

	Cost per foot of tunnel.
Excavation	$11.10
Engineering	.21
Adit proportion	.08
Permanent equipment	2.35
Timbering (916 feet)	1.83
	$15.57

Tunnel 7, Length 3,596 Feet.

(Through biotite granite of variable hardness at an average speed of 140 feet per month.)

	Cost per foot of tunnel.
Excavation	$13.55
Engineering	.27
Adit proportion	.13
Permanent equipment	2.35
Timbering (3,609 feet)	3.60
	$19.90

Tunnel 8-S for 1,334 Feet.

(Through medium-hard to hard granite at an average speed of 135 feet per month.)

	Cost per foot of tunnel.
Excavation	$12.82
Engineering	.19
Adit proportion	.18
Permanent equipment	2.35
Timbering (126 feet)	.39
	$15.93

Tunnel 9 for 3,506 Feet.

(Through medium hard to hard granite at an average speed of 195 feet per month.)

	Cost per foot of tunnel.
Excavation	$12.19
Engineering	.18
Adit proportion	.07
Permanent equipment	2.35
Timbering (305 feet)	.29
	$15.08

Tunnel 10 for 5,657 Feet.

(Through medium-hard to hard granite at an average speed of 200 feet per month.)

	Cost per foot of tunnel.
Excavation	$13.50
Engineering	.19
Permanent equipment	2.35
Timbering (194 feet)	.11
	$16.15

Tunnel 10A-N for 1,496 Feet.

(Through medium-hard to hard granite at an average speed of 165 feet per month.)

	Cost per foot of tunnel.
Excavation	$13.02
Engineering	.13
Permanent equipment	2.35
Timbering (24 feet)	.78
	$16.28

Tunnel 10A-S for 2,200 Feet.

(Driven through medium-hard to hard granite at an average speed of 200 feet per month.)

	Cost per foot of tunnel.
Excavation	$12.37
Engineering	.20
Permanent equipment	2.35
Timbering (215 feet)	1.15
	$16.07

Grapevine Division Tunnels.

Location: Kern County, Cal.

Purpose: Water supply, power and irrigation.

Cross-section: Straight walls, arched rod, dished bottom.

Size: 7 feet 10 inches wide by 8 feet 5 inches high.

Type of power: Electric power purchased from aqueduct plant.

Ventilators: Pressure blowers.

Size of ventilation pipe: 12 inches.

Drills: Pneumatic hammer, usually 2 in each heading.

Mounting of drills: Horizontal bar.

Number of holes per round: Usually 18 to 20.

Average depth of round: 6 to 8 feet.

Number of drillers and helpers per shift: 2 drillers and 2 helpers.

Number of drill shifts per day: Usually 2.

Explosive: 40 per cent. ammonia dynamite, but 60 per cent. and 75 per cent. gelatine dynamite were employed in hard ground.

Number of muckers per shift: 4 or 5.

Number of mucking shifts per day: Usually 2.

Type of haulage: Electric after the first 400 to 500 feet.

Wages: Drillers and helpers $3, muckers $2.50, blacksmiths $4, helpers $2.50, motormen $2.75, dumpmen $2.50.

Tunnel 12, Length 4,900 Feet.

(Through hard granite at an average speed of 185 feet per month.)

	Cost per foot of tunnel.
Excavation	$22.10
Engineering	.32
Permanent equipment	2.35
Timbering (90 feet)	.08
	$24.75

Tunnel 13 for 1,525 Feet.

(Through hard granite at an average speed of 130 feet per month.)

	Cost per foot of tunnel.
Excavation	$20.60
Engineering	.10
Permanent equipment	2.25
Adit proportion	.37
	$23.32

Tunnel 14, Length 859 Feet.

	Cost per foot of tunnel.
Excavation	$22.70
Engineering	.13
Permanent equipment	2.25
Adit proportion	.72
Timbering (22 feet)	.16
	$25.96

Tunnel 15, Length 895 Feet.

	Cost per foot of tunnel.
Excavation	$23.28
Engineering	.11
Permanent equipment	2.25
Adit proportion	2.42
	$28.06

Tunnel 16, Length 2,723 Feet.

(Through hard granite at an average speed of 145 feet per month.)

	Cost per foot of tunnel.
Excavation	$20.07
Engineering	.17
Permanent equipment	2.25
Adit proportion	.55
Timbering (18 feet)	.04
	$23.08

Tunnel 17, Length 3,024 Feet.

	Cost per foot of tunnel.
Excavation	$20.47
Engineering	.21
Permanent equipment	2.25
Timbering (142 feet)	.22
	$23.15

Tunnel 17½ for 1,345 Feet.

(Through medium-hard to hard granite at an average speed of 225 feet per month.)

	Cost per foot of tunnel.
Excavation	$19.56
Engineering	.31
Permanent equipment	2.25
	$22.12

Tunnel 17A for 3,275 Feet.

	Cost per foot of tunnel.
Excavation	$18.70
Engineering	.17
Permanent equipment	2.25
Timbering (441 feet)	1.18
	$22.30

Tunnel 17B for 4,915 Feet.

	Cost per foot of tunnel.
Excavation	$21.09
Engineering	.21
Permanent equipment	2.25
Timbering (163 feet)	1.90
	$25.45

ELIZABETH DIVISION, ELIZABETH LAKE TUNNEL.

Location: Los Angeles County, Cal.

Purpose: Water supply, power and irrigation.

Cross-section: Rectangular, with arched roof.

Size: 12 by 12 feet.

Length: 26,870 feet.

Type of power: Electric power purchased from aqueduct plant.

Ventilator: Pressure blower.

Size of ventilating pipe: 18 inches.

Drills: Pneumatic hammer, 3 in the south heading and 2 in the north.

Mounting of drills: Horizontal bar.

Number of holes per round: 25 in the south heading, 16 in the north heading.

Average depth of round: 8 to 10 feet.

Number of drillers and helpers per shift: 2 drillers and 2 helpers at the north end, 3 drillers and 3 helpers at the south end.

Number of drill shifts per day: 3.

Explosive: 40 per cent. and 60 per cent. gelatine dynamite.

Number of muckers per shift: 6.

Number of mucking shifts per day: 3.

Type of haulage: Electric.

Wages: Drillers and helpers \$3, muckers \$2.50, blacksmiths \$4, helpers \$2.50, motormen \$2.75, dumpmen \$2.50.

Maximum progress in any calendar month: 604 feet, April, 1910.

Average monthly progress per heading: 350 feet per month.

North Heading, Elizabeth Lake Tunnel.

(Through altered granite, requiring much timbering, 13,370 feet.)

	Cost per foot of tunnel.
Drilling and blasting	\$11.25
Mucking and tramming	11.70
Engineering and superintendence	1.27
Drainage	.45
Ventilation	.22
Light and power	5.55
Timbering (13,031 feet)	8.48
Cost of auxiliary shaft	.93
Permanent equipment (full charge, no salvage; estimated)	3.70
	\$43.55

South Heading, Elizabeth Lake Tunnel.

(Through medium-hard to hard granite, requiring but little timbering, 13,500 feet.)

	Cost per foot of tunnel.
Drilling and blasting	\$14.65
Mucking and tramming	11.10
Engineering and superintendence	.86
Drainage	.17
Ventilation	.41
Light and power	4.93
Permanent equipment (without salvage; estimated)	3.70
Timbering (3,424 feet)	2.19
	\$38.01

Lucania Tunnel.

Location: Idaho Springs, Colo.

Purpose: Mine development and transportation.

Cross-section: Square.

Size: 8 by 8 feet.

Length: 12,000 feet projected; 6,385 feet driven December 1, 1911.

Character of rock penetrated: Hard granite.

Type of power: Purchased electric current.

Ventilator: Pressure blower.

Size of ventilating pipe: 18 and 19 inches.

Drills: Pneumatic hammer, 3 in the heading.

Mounting of drills: Vertical columns.

Number of holes per round: 25.

Average depth of round: 8 to 9 feet.

Number of drillers and helpers per shift: 3 drillers and 2 helpers.

Number of drilling shifts per day: 1.

Explosive: 50 per cent. gelatine dynamite.

Number of muckers per shift: 3.

Number of mucking shifts per day: 1.

Type of haulage: Horses.

Wages: Head driller \$5, drillers \$4, nipper \$3.50, boss mucker \$5, muckers \$4, drivers \$4, power engineers \$4, blacksmith \$5.

Maximum progress in any calendar month: 263 feet, September, 1911.

Average monthly progress: 125 feet per month for the first 4,800 feet, 240 feet per month for the last 1,575 feet.

Average Cost of Driving First 4,800 Feet.

	Cost per foot of tunnel.
Labor	\$ 8.86
Powder	7.86
Fuse and caps	.17
Candles and oil	.21
Horse feed and shoeing	.18
Power	1.64
Repairs	.14
Tunnel equipment	2.75
Surface plant	1.25
	\$23.06

"Tunnel equipment" includes the cost of materials and installation of the pressure air line, the ventilating line, rails, ties and fittings, and the drainage ditch. "Surface plant" includes buildings, compressor, blower, transformers, motors and drill sharpener.

Cost of Driving Next 1,575 Feet.

The contractor received \$21.50 per foot to cover the cost of labor, powder, fuse, caps, candles, oil, horse feed and shoeing, power and repairs, and the installation of the tunnel equipment.

(To be continued.)

REMARKABLE SPEED IN BRIDGE BUILDING.

Since the establishment of the Canadian military camp at Valcartier, Que., there has been much accomplished that reflects credit upon the manner in which the engineering features of the camp have been handled. First, it took but a few days for the Canadian Northern Railway to transform a small flag station into an important terminal point with twenty miles of railway sidings, giving a splendid impetus to the establishment of the camp and expediting the movement of the men and materials which went to make this city of thirty thousand souls.

Now comes news of a bridge-building record made by the men of the Royal Canadian Engineers under the direction of Major W. Bethune Lindsay, of Winnipeg. The Jacques Cartier River separates the main camp from the artillery practice grounds at the base of Mounts Ileene and Irene. Across this 350 feet of waterway, the Royal Canadian Engineers built in four hours, a barrel-pier pontoon bridge, capable of carrying heavy batteries. The major and his three hundred men worked with that well ordered efficiency which characterizes the efforts of the British bred. The race for the record started with the Canadian Northern Railway. The materials—barrels, planking, etc., were freighted on to the ground with remarkable despatch. The casks were made watertight, the timber was made ready, the twenty-foot bank cut down to provide an easy grade for traffic, and the actual test was on.

There is a telephone for every 15.2 persons in Canada, according to official figures.

Promising surface indications of petroleum deposits in Spain have led the government to investigate the discoveries.

Editorial

HAMILTON-TORONTO PERMANENT HIGHWAY.

The plan to proceed without delay on the construction of a $600,000 permanent highway between the cities of Hamilton and Toronto is a very commendable one. Besides providing a thoroughfare for which there has been a distinct need, this work will be a boon to many unemployed in the two terminal cities and in the intervening municipalities.

Various organizations, including city and town councils, boards of trade, automobile, farmers' and fruit-growers' associations, etc., have emphasized for a considerable length of time the necessity for a permanent road which, when constructed, would serve over half a million people. The road will run through fruit and vegetable farming communities for practically its entire length and will be a means of bringing producer and consumer closer together here than it is possible to find them elsewhere in the Dominion. The phrase "deplorable condition" has been associated with the present Lake Shore Road for the greater part of many seasons. This state is very regrettable considering the usefulness of an improved inter-city highway, its picturesqueness and the absence of engineering difficulties along its path.

Last week a program was decided upon by the Provincial Government whereby Toronto and Hamilton will contribute $150,000 and $30,000 respectively, while the counties through which the projected road will pass will assist at the rate of $4,000 per mile. A commission was also appointed to properly manage these funds, to select the route, concerning which, for a small portion of the distance, there has been some controversy, to decide the type of pavement and to take charge of the construction. This commission consists of Geo. H. Gooderham, M.P.P., Toronto; G. Frank Beer, Toronto; T. W. Jutton, Hamilton; M. C. Smith, Burlington; and C. G. Marlatt, Oakville.

The last report of the Public Roads and Highways Commission of Ontario very strongly emphasized the need of this permanent inter-city route. One of its chief recommendations for this season's work constituted a preliminary survey of the line. The government authorized this procedure last winter, and Mr. W. A. McLean, the Provincial Highway Engineer, has had a staff of men engaged upon the work for a greater part of the summer. Hence, little time need be spent upon preliminaries.

What remains of the road-making season has been reduced to a matter of days, but before the interference of severe weather, any necessary re-location may be made, grading may be proceeded with and materials collected. This may mean the employment of from 500 to 700 men.

It is just such undertakings as these, involving the services of large gangs of men, that our cities and towns should hasten to proceed with, in order to reduce as much as possible the distress and want which follows in the wake of unemployment.

ANNOUNCEMENT

In view of the present political conditions in Germany and Austria, which constitute a menace to Canadian interests, *The Canadian Engineer* feels fully justified in excluding from its pages the advertisements of any machinery or materials made in Germany or Austria that can be supplied by Canadian firms, by firms situated anywhere within the British Empire, or by firms in the friendliest of neutral countries, the United States.

ENGINEERS' LIBRARY

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer.

CONTENTS.

BOOK REVIEWS.

Influence Diagrams for the Determination of Maximum Moments in Trusses and Beams. By Malverd A. Howe, C.E., Professor of Civil Engineering, Rose Polytechnic Institute. Published by John Wiley & Sons, New York; Canadian consulting agents, Renouf Publishing Co., Montreal. 65 pp.; 42 illustrations; 6 x 9 in.; cloth. Price, $1.25.

This is the first edition of a very useful work which explains the method of applying influence lines in the analysis of trusses, arches and beams. While their use is not new, the book has for its object the directing of attention to the fact that for loads on all ordinary trusses the influence diagrams for bending moments may be drawn by following a single simple rule and that no computations are required for the direct application of such diagrams when so constructed. In addition, it also brings out the fact that these influence diagrams for loads on continuous trusses, cantilever trusses and arches are based upon the one general diagram for simple trusses. Moreover, the author makes it clear that although the diagrams shown in the book are constructed for moments, yet they can be as easily drawn to indicate stresses or even areas of truss members.

The work is divided into five chapters: Simple trusses, double intersecting trusses, continuous trusses, arches and beams of constant section.

The definition of influence line as given by the author is a very convenient one, viz., "an influence line is one which shows the effect of a unit load moving across a structure upon any function of the structure for any position of the load." As might be expected, the work contains many technical calculations, but they are well illustrated in the diagrams and carefully explained in the text.

The work is well printed and bound, and a structural engineer will find it a valuable addition to his library.

Lackawanna Handbook. Published by the Lackawanna Steel Co., Buffalo, N.Y. 456 pp.; size 4 x 6½ in.; flexible leather binding. Price, $2.00.

This is a 1915 edition of a handbook containing some very useful information for engineers, architects and builders. It comprises diagrams, dimensions and weights of structural steel sections, special shapes merchant bars, sheet steel filing, standard heavy and light rails, track accessories, etc. The usual mathematical tables required in the use of such products are included. Among them might be mentioned the properties of rolled sections; the dimensions, properties and safe loads of steel columns and struts, and the dimensions and safe loads of girders and beams. The handbook also contains mensuration formulæ, notes on roofs and roof trusses, tables of weights, measures, specific gravities and others for arithmetical and logarithmic use.

Waterworks Engineering. By Fred. C. Uren, M. Inst. C.E. Published by Castle Litho, Limited, Bristol, Eng. 270 pp.: 186 illustrations besides numerous plates; size 6 x 9½ in.; cloth.

The author's wide experience in waterworks engineering, comprising company, local authority and parliamentary work is reflected throughout this book, which will be found a practical treatise on the construction of waterworks and therefore of benefit to engineers and engineering students. The work fills a want that has been more or less ignored by many volumes on waterworks engineering that have appeared throughout recent years. The theoretical side of the question has been treated with special brevity in order to devote all possible space to details of actual construction of small and large undertakings from their incipient stages to completed works. The author has recognized the fact that improvements that recent years have brought about in many phases of design and construction, have almost revolutionized former practice; hence, such sections as those on earthen and masonry dams, geology and well boring, distribution and purification, have been given special attention.

The following constitute the chapter headings: Sources—Storage; Impounding Reservoirs, Masonry Dams; Earthwork Dams; Reservoir Accessories; Rivers and Streams; Well Construction and Boring; Geology, Yield of Wells; Service Reservoirs; Raising Water from Wells; Motors for Pumps; Calculating the Dimensions of Pumps and Engines; The Flow of Water in Pipes and Channels; Gauging Water; The Purification and Softening of Water; Distribution and Utilization; Watermains and Accessories; Service Pipes and House Fittings; Metered Supplies, Waste Detection; Administration and Maintenance; and, The Law of Waterworks.

Work, Wages and Profit. By H. L. Gantt. Published by the Engineering Magazine Co., New York. 312 pp.; 27 illustrations; size 5 x 7 in.; cloth. Price, $2.00.

This is the second edition of Mr. Gantt's book. It is considerably revised and enlarged over the first edition which appeared in 1910. The author has taken advantage of the rapid rise that has taken place in public attention to the methods used and the results secured in the application of scientific management to the various industries. In his preface the author is cautionary concerning sudden

changes of management for purposes of inaugurating the principles of modern industrial organization into an industry. He states: "The man who undertakes to introduce scientific management and pins his faith to rules, and the use of forms and blanks, without thoroughly comprehending the principles upon which it is based, will fail. Forms and blanks are simply the means to an end. If the end is not kept clearly in mind, the use of these forms and blanks are apt to be detrimental rather than beneficial."

The work goes a long way towards explaining the principles of modern industrial organization and outlines how to utilize the methods of evolution in the introduction of a system of management based upon these principles. The author's experience in the field of labor management extends over 25 years of close practical application and his own special methods are well known, although perhaps partially or imperfectly understood by many. The book outlines to the full his concept of scientific investigation according to standardization, individual instruction, and interconnected reward to both instructor or supervisor and workman.

The illustrations are for the most part in the form of colored charts, representing conditions associated with scientific management in machine shop, metal working, locomotive building plants, etc.

In its entirety the work offers an interpretation of industrial conditions and a promise for betterment that makes it of extreme value to the managers of industry.

Sub-Aqueous Foundations. By Chas. E. Fowler, M. Am. Soc. C.E., M. Can. Soc. C.E., etc. Published by John Wiley & Sons, New York; Canadian selling agents, Renouf Publishing Co., Montreal. 814 pp.; 477 illustrations; size 6 x 9 in.; cloth.

This extensive treatise on Sub-aqueous Foundations is the third edition of Mr. Fowler's work, considerably revised and enlarged. It includes in revised form the material of several previous publications by the author, the cofferdam process for piers, and dredges and dredging. It is a practical treatment of the whole subject containing numerous examples from actual work. This latter characteristic largely constitutes a new matter incorporated in the third edition. They relate to structures that have had the test of time and use. Many of them were constructed by the author or were under his supervision in a consulting capacity.

The use of compressed air in caisson work has been conspicuously added to, while an entire chapter has been devoted to the use of launches, tugs and scows, as required in foundation work. Characteristic of the publication is the data also on the bearing power of soils, on friction in pile and caisson work and on the quarrying of rock. Entirely new matter has been given on piers and wharves; dams, sea walls and retaining walls; dry docks and locks; cost of construction work, the two chapters on this latter subject covering the subject of foundations so well that the engineer in possession of the volume will find it quite adequate as a source of information to properly execute his work.

The following list of chapter headings is sufficient evidence of the comprehensiveness of the book, and engineers familiar with the author's previous contributions to literature on the subject no doubt find therein sufficient new matter to assure them that the book will fill a very important place:

Historical Development; Construction and Practice—Crib Cofferdams; Construction and Practice—Cribs and Canvas; Pile-Driving and Sheet-Piles; Jetting Piles; Construction with Sheet-Piles; Metal Construction; Cylinders and Caissons; Open Dredged Caissons of Timber; Timber Pneumatic Caissons; Steel Pneumatic Caissons, Forth Bridge; Divers and Diving; Removing Old Piers; Pumping and Dredging; Clam-shell Dredges, Drill Scows and Rock Breakers; Dipper and Ladder Dredges; Suction and Hopper Dredges; Tugboats and Scows; The Foundation; Location and Design of Piers; Rock Fill Foundations and Quarries; Calculation of Piers, Footing and Retaining Walls; Cement and Concrete; Foundations for Piers and Wharves; Timber Piers and Timber Preservation; Foundations for Dams, Sea Walls, and Breakwaters; Foundations for Docks and Locks; Forms for Concrete; Estimating the Cost.

Symmetrical Masonry Arches. By Malverd A. Howe, M. Am. Soc. C.E., professor of Civil Engineering, Rose Polytechnic Institute. Published by John Wiley & Sons, New York; Canadian selling agents, Renouf Publishing Co., Montreal. 245 pp.; 35 illustrations; 6 folding drawings; size 6 x 9 in.; cloth. Price, $2.50.

This is the second edition of Professor Howe's treatise on the design of masonry arches according to the elastic theory. Most of the text has been rewritten and a considerable amount of new matter added, while demonstrations of the formulas presented in the previous edition have been materially simplified. The author has employed the unit load method throughout the work, claiming it to be the only satisfactory method to use if maximum stresses are desired.

In order to facilitate a ready solution of the ordinary problems, such as are encountered by the engineer during his regular practice, a greater portion of the book is taken up with the solution of examples, each step being given in detail so as to be readily followed by the engineer or engineering student who has not specialized particularly along this line.

The general subject is treated under the divisions of: Fundamental Formulas; Symmetrical Arches fixed at the ends (2 chapters); Examples showing the application of the formulas; and Typical Arches.

The work relates generally to masonry arches of natural stone, plain concrete and reinforced concrete. Appendices to the general text are as follows: Physical properties of stone and concrete; Data for about 600 arch bridges.

PUBLICATIONS RECEIVED.

Queen Victoria Niagara Falls Park.—28th annual report of the Commissioners (1913). 42 pages; illustrated; size, 6 x 9 in.

Hydro-Electric Power as Applicable to the Farm.—Evidence given before select standing committee on Agriculture and Colonization, Canada.

Experiments with Furnaces for a Hand-Fired Return Tubular Boiler.—Technical Paper No. 34 of the United States Bureau of Mines. 32 pages; size, 6 x 9 in.

Association of Ontario Land Surveyors.—Proceedings of the 22nd annual meeting, held in Toronto, February, 1914. It contains reports of committees, papers, list of members, etc.

Electric Lights for Use About Oil and Gas Wells.—Technical Paper No. 70 of the United States Bureau of Mines outlining danger from use of ordinary electric lights, suggested specifications, etc.

Ontario Good Roads Association.—Proceedings of the 12th annual meeting, appended to the annual report of the

Commissioner of Highways. It contains the papers, discussions and reports of the February, 1914, meeting.

Proportioning Aggregates for Portland Cement Concrete.—Reprint of paper by Albert Moyer from the proceedings of the American Society for Testing Materials. Issued by the Vulcanite Portland Cement Co., New York.

Accidents from Falls of Rock or Ore.—A circular issued by the United States Bureau of Mines outlining the causes and prevention of accidents from such falls under different conditions of mining, and general hints to miners on the subject.

Forestry.—Report for 1913 of the Director of Forestry, Department of the Interior, Canada, containing the reports also of district inspectors, inspector of fire ranging, and reconnaissance surveys in various Provinces. 136 pages; illustrated.

Trent Watershed Survey.—Map illustrating forest distribution and diagram showing classification of land to accompany previous report of the Commission of Conservation, Ottawa, on the Trent Watershed Survey (already reviewed in these columns).

Tabulation of Water Rates.—Report of Committee on Tabulation of Water Rates and other information of interest to water companies. 337 pages; size, 6 x 9 in.; reprinted from the Journal of the American Waterworks Association, for June, 1914.

Centrifugal Compressors.—By Louis C. Loewenstein, Issued by the Canadian General Electric Co., and reprinted from the General Electric Review. A very comprehensive discussion of the design, construction and operation of centrifugal compressors.

Lands, Forests and Mines.—Report for 1913 of the Minister of Lands, Forests and Mines of the Province of Ontario, including statements and reports of officers, surveyors, superintendents and of Mr. J. F. Whitson on the construction of roads in Northern Ontario.

The Pre-Cambrian Geology of Southeastern Ontario.—By W. G. Miller and C. W. Knight, of the Bureau of Mines of Ontario. The report also contains an appendix on the co-relation of the Pre-Cambrian rocks of Ontario, Western Quebec and Southeastern Manitoba.

Mother Lode and Sunset Mines Boundary District, B.C.—Memoir No. 19, of the Geological Survey, Department of Mines, Canada. Compiled by O. E. LeRoy. It covers the general character of the district, its general and economic geologies and detailed description of the mines.

Clay and Shale Deposits of the Western Provinces.—Part No. 3.—By Heinrich Ries. Memoir No. 47 of the Geological Survey, Department of Mines, Canada. Report of the 1912 investigation of the Survey, including field work and results of tests of samples from a large number of localities in Western Canada.

Factors Governing the Combustion of Coal in Boiler Furnaces.—A 44-page preliminary report issued by the United States Bureau of Mines. It describes the equipment and character of tests constituting an extensive investigation; the coal used; results of the experiments; and discussion of results of tests.

Big Creek Initial Development.—1914 report of the Stone and Webster Construction Co., describing their work in connection with 4 dams, 2 tunnels, 2 power-houses, 2 240-mile transmission lines, sub-station and 56-mile railroad for the Pacific Light and Power Corp. Beautifully illustrated with photographs and colored map.

The Origin of Coal.—Bulletin No. 38, United States Bureau of Mines. 390 pages; illustrated; size, 6 x 9 in. It deals with the geologic relations of coals; analysis of samples; physiographic conditions attending coal formation; rate of deposition; origin and formation of peat; microscopic study of coal, and conclusions.

The Young Man and the Electrical Industry.—A reprint by the Westinghouse Electrical and Manufacturing Co. of an article by Jas. H. Collins dealing with the opportunity afforded a young man in the industry and the different lines in which he may direct his activities as exemplified in the works of that company. Article appeared in "Scientific American," May 16th, 1914.

International Joint Commission.—Opinions, reports of hearings and arguments, and orders of the International Joint Commission in the matter of (1) the application of the Michigan Northern Power Co. for approval of the obstruction, diversion and use of St. Mary's River water on the United States side of the boundary at Sault Ste. Marie, and (2) the application of the Algoma Steel Corp. upon the same problem.

Vitrified Brick, Pavements and Highways.—Specifications for the construction of vitrified brick street pavements and highways, being the 1914 revised edition issued by the National Paving Brick Manufacturers' Association. The specifications cover grading; drainage; stone curbing; concrete foundation; cushion; expansion joints; brick; bricklaying and inspection; rolling; cement grout filler; alternative concrete curbing; with similar specifications concerning cement-filled brick pavement; crushed stone; old gravel or macadam foundation; sand filler; in the case of each, i.e., street pavements and highways.

Poor's Manual of Industrials for 1914 (fifth annual number).—The book contains 2,500 pages, or about 300 pages more than any previous issue. About 750 new companies have been added and many new income accounts and balance sheets. These tables are mostly in comparative form. In addition, the Manual contains an appendix, giving late information on the Railroads and Utilities, supplementing these two Manuals. The publication of this volume completes Poor's Manual for 1914. The three books together contain over 6,500 pages, covering the entire field of corporate investment in America. They give statements of practically every corporation in which there is a public interest, and are noted for their accuracy, completeness and thoroughness.

CATALOGUES RECEIVED.

Morris Overhead Runway.—An illustrated bulletin of the Herbert Morris Crane and Hoist Co., Limited, Toronto, describing the "O. E. F." type of runway as to capacities, construction, accessories, etc.

Storage Battery Locomotives.—A 4-page leaflet issued by the Canadian Westinghouse Co., Limited, Hamilton, Ont., descriptive of the Baldwin-Westinghouse Storage Battery Locomotives, as built in two types for mining and industrial service.

Work Done.—A 48-page illustrated booklet issued by Westinghouse, Church, Kerr and Co., New York, descriptive of some of the work which they have done for industrial plants. The work includes railways, steam and electric, as well as the design and construction of complete plants, etc.

Oil and Gas-Burning Appliances.—An 8-page bulletin issued by the Quigley Furnace and Foundry Co., Springfield, Mass., descriptive of appliances for burning oil and gas fuel, including burners, blowers, strainers, separators, regulating valves, gauges, storage tanks, pumping systems, etc.

Evidence as to Pavements.—A handsomely illustrated booklet published by the Barber Asphalt Paving Company, Philadelphia, describing the work done by them in various cities of the United States, and outlining the durability of such pavements as evidenced by many instances in which they are more than 20 years old.

Rail Bonds and Bonding Tools.—A catalogue issued by the Canadian General Electric Co., Toronto, and containing

information on rail bonds and rail bond tools for various requirements. Recent improvements are described and a considerable quantity of engineering data included. The catalogue is well illustrated and covers 54 pages.

Floor and Ceiling Plates.—A catalogue of special interest to heating and plumbing trades descriptive of various types of plates, automatic wood wheel and key valves, self-cleaning water gauges and various other accessories for steam and hot water systems. Published by the Beaton and Cadwell Manufacturing Co., New Britain, Conn.

Lagonda Multiple Strainers.—It describes a strainer manufactured by the Lagonda Manufacturing Co., Springfield, O., for water intake lines of power plants and pumping stations for the removal of solid matter without any interruption to flow. The catalogue contains much descriptive information; it is well illustrated, and covers 20 pages.

Railway Motor Gears and Pinions.—A 20-page bulletin issued by the Canadian General Electric Co., Toronto, describing their various grades of gears and pinions. The description covers solid cast-steel, split cast-steel and forged gears. It explains their construction and gives some valuable gear formulæ, together with tables of classification and dimensions.

Oil and Gas Engines.—A 50-page catalogue issued by the August Mietz Iron Foundry and Machine Works, New York, descriptive of Mietz and Weiss oil and gas engines, stationary and marine, for operation by kerosene, alcohol, fuel oil, distillate and crude oil; 2 to 400 h.p. Also a catalogue descriptive of Mietz and Weiss marine oil engines, reversing friction clutches, starters, etc.

Chloride and Tutor Accumulators.—A 24-page catalogue issued by the Canadian General Electric Co., Limited, Toronto, descriptive of these types of accumulators for electric railways, central and isolated lighting and power plants, interlocking switch and signal service, telephone, telegraph, fire alarm, laboratory and small motor work. The catalogue describes both types in detail as to sizes, capacities, working conditions, parts, etc.

Measuring Tapes and Rules.—A handsomely illustrated and well-bound 110-page catalogue published by the Lufkin Rule Co. of Canada, Limited, Windsor, Ont., as Catalogue No. 9. A wide assortment of tapes and their accessories, including hooks, tension handles, reels, arrows, as well as a large variety of steel and boxwood rules, yard-sticks, squares, etc., as required by engineers, contractors, surveyors, lumbermen, etc.

Motor-Driven Pumps.—Catalogue No. 3,002-A of the Canadian Westinghouse Co., Hamilton, Ont., describing in 24 pages the motors which that company manufactures for driving all types and sizes of pumps. The catalogue contains quite a supply of information on the requirements of pumps for sewage disposal systems, waterworks, mines, industrial plants, fire departments, irrigation work, dry-docks, contractors' use, etc.

Appliances for burning Fuel Oil.—A large, handsomely illustrated 32-page catalogue issued by the Tate, Jones and Co., Inc., Pittsburgh. It outlines the economy of oil for steam production; the advantages of oil fuel for furnaces; the importance of the burner to success with fuel oil, giving actual results in each case. The remainder of the catalogue describes the company's types of burners, and systems of pumping, heating and regulating oil flow.

BOARD OF HEALTH APPROVALS.

During the week of September 7th the Provincial Board of Health of Ontario approved of the sewer extensions of Arnprior, Kingston and New Liskeard. Water mains for the city of Toronto were also approved of.

Coast to Coast

Moncton, N.B.—The gates of Moncton's new 50-foot reservoir are now closed, according to the recent announcement of City Engineer Edington; and when it has been flushed sufficiently to remove all debris, a water supply will be turned on in the town. It is expected that the supply will be available in about two months' time.

Gagetown, N.B. Finishing touches are being given to the rail-bed of the Valley Railway, which will connect Gagetown and Fredericton, and over which it is fully expected a service will be commenced this winter. Rails have been laid as far as the station, and the station building has been completed. The water tank at the station is not yet in working order. The well in connection with the tank has been dug to a depth of 200 feet; but this depth does not give sufficient depth for the flow of 40,000 gallons per day which is required.

St. John, N.B.—The Dominion Bridge Company has practically reassembled its construction plant at the eastern side of the river at the Falls. The trestle, which starts below the rock cut on the C.P.R. track and crosses over at the corner of Chesley Street to the approach of the bridge, has been finally connected; and the granite work on the skew-back piers on the east side are being finished by Messrs. J. McVey and Son. Within a few days, the Bridge company will be ready to swing out the steel on the eastern part of the arch to complete the bridge.

Saskatoon, Sask.—It is stated that in connection with the work on the large reinforced concrete bridge being erected at Saskatoon, the contractor has installed a pneumatic concrete mixing plant, a patented mixer, in which the mixing is done by compressed air and the concrete is transferred from the mixer to the point of disposal under air pressure. Also the difficulty which was experienced last winter in constructing the river pier third from the east abutment causing this work to be left unfinished, has been overcome; and now but one pier on the whole work remains to be undertaken.

Valcartier, Que.—Since the action of the Dominion Government making Valcartier on the C.N.R. the centre for the Canadian military camp, the railway company has constructed a main line, 8,800 feet long, from mileage 15.05 to a point on the Gosford branch of the system. On this line, 3 sidings have been laid as the main transfer point: one of these is double-ended, the other two entering only from the west. Several additional sidings have also been built, and a 12-degree loop from the west end to the sidings is connected with the Gosford line in the return direction. The engineering work for this new terminal was supervised by Mr. C. H. N. Connell, engineer of maintenance of way on the C.N.R.

Ottawa, Ont.—An announcement made at Ottawa at the beginning of this month stated that Canada has taken over the wireless stations at Port Nelson and The Pas. The stations were erected with government funds by the Marconi company, which had the contract to operate them for a year. The period for their operation by the Marconi company is expiring. It has been decided that the operation hereafter can be best carried on by the wireless branch of the naval service department. The two stations will form part of a wireless chain which the government proposes to provide for Hudson Bay. Both The Pas and Nelson stations are equipped with apparatus of high power. They have a despatching reach of 400 miles overland. Other stations will be erected further north. There will be one on Maunsel Island, at the western

extremity of Hudson Strait, one at Ash Inlet, about the centre of the Strait, and one at Button Islands, at the Atlantic end of the Strait. When these stations are completed it will be possible to speedily convey and receive information over the whole Hudson region.

PERSONAL.

Col. W. P. ANDERSON, C.M.G., chief engineer of the Department of Marine and Fisheries, Ottawa, is in British Columbia on his annual inspection of the works under the control of that department.

D. L. H. FORBES, B.A.Sc., M.E., has been appointed chief construction engineer of the Chile Exploration Company of Chuquicamata, Chile. For some time Mr. Forbes had carried on a consulting mining engineering practice, with offices in Toronto.

Major E. C. NORSWORTHY was last week elected a director of the Canada Cement Company, Montreal. Major Norsworthy, who is at present with the Royal Scots Regiment at Valcartier, is a director of the Dominion Securities Corporation, and its manager for Montreal.

PERCY WILGER, formerly an engineer on the National Transcontinental Railway, has been appointed Professor of Civil Engineering, School of Mining, Queen's University, Kingston. Mr. Wilger is a Queen's graduate of 10 years' standing. He succeeds the late Professor A. K. Kirkpatrick.

E. S. CLEMENTS of the Canada Creosoting Co., Limited, Toronto and Trenton, Ont., has resigned.

OBITUARY.

The death is reported of Mr. Jas. A. Gould, Edmonton superintendent for the Bitulithic Paving Company. Seven years ago Mr. Gould resigned from a position as street superintendent of the City of Toronto to take a position in Edmonton for the above company. In 1910 he resigned to become superintendent of streets for Edmonton, but in 1913 he returned to the employ of the paving firm. Mr. Gould's death was quite sudden and unexpected, heart failure being the cause.

The death occurred last week of Mr. Fred. H. Herbert, a prominent architect of Toronto.

Our readers will no doubt remember the controversy which followed the disastrous storm of November 9th, 1913, and its heavy toll of life and traffic on the Great Lakes. *The Canadian Engineer* of December 11th, 1913, published some valuable suggestions as to the possible prevention of similar disasters to inland freighters from the pen of Mr. Wm. E. Redway, Naval Architect, Toronto. We regret at this time to be called upon to report the death of Mr. Redway, on September 19th, 1914. Since 1884 he had been associated with shipbuilding in Canada, during which period he designed many improvements, and received honored recognition from various naval organizations within and outside the Empire.

CORRECTION IN ADDRESS.

In the advertisement of the De Laval Steam Turbine Co. for several weeks past, the address of the Turbine Equipment Co., Limited, Toronto, who are the Canadian representatives of the De Laval Steam Turbine Co., has been given in error as 204 Peterkin Building. The correct address of the Turbine Equipment Co., Limited, is the Canadian Pacific Building, King and Yonge Streets, Toronto, to which they moved a few weeks ago from the Peterkin Building.

C.G.E. CORPS OF ENGINEERS.

In connection with the mustering of Canadian troops the Canadian General Electric Co. has established a corps of engineers, both electrical and mechanical, and has divided it into three sections to serve at Quebec, Halifax and Esquimalt. The company is maintaining six corps of technical men at its own cost throughout the duration of the war. Prior to taking their departure from Toronto for their respective posts of duty Mr. Frederic Nicholls, President of the General Electric Company, delivered a parting address to the men, exhorting them to be as consistent in the service which they are undertaking as they had been in the service of the company.

The personnel of the three detachments is as follows:—

For Quebec—Messrs. W. J. Swanger, R. W. Nurse, George Monaghan, George Hillier, C. Pink, P. Foster, H. Galvin, of Peterboro, and Colin C. Rous, of Toronto.

For Halifax—Messrs. H. S. McKean, J. C. Munro, Clarence Henry, E. S. Shill, R. Bethune, A. J. Palmer, of Peterboro, and F. G. Jackson, Edward Crockford, of Toronto.

For Esquimalt—Messrs. H. Ritchie, Chas. Stewart, H. E. Elliott, W. S. Johnson, H. Williams, J. S. Dunlop, of Peterboro, and A. T. McLean, Harold Bestard, Alex. Hardie, of Toronto.

COMING MEETINGS.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.

MOTOR TRUCK CLUB OF AMERICA.—Annual Convention, Detroit, Mich., October 7th to 9th. President, George H. Duck, New York City.

GULF AND INTEROCEAN NATIONAL HIGHWAY ASSOCIATION.—October 8th, 9th, 10th; conference to be held at New Orleans, La. Secretary, Jno. B. Kent, Lake Charles, La.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.—Annual Convention, Grunewald Hotel, New Orleans, La. October 20th to 23rd. Secretary, Mr. McFall, Roanoke, Va.

ALABAMA GOOD ROADS ASSOCIATION. — Nineteenth Annual Convention will be held from October 21st to 23rd at Montgomery, Ala. Secretary, J. A. Rountree, 1021 Brown Marx Building, Birmingham, Ala.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Charles Carroll Brown, Secretary, Indianapolis, Ind. Meets at Somerset Hotel, Boston, Mass., October 21st, 22nd and 23rd.

NORTHWESTERN ROAD CONGRESS.—Annual Convention, to be held at Milwaukee, Wis., October 28th to 31st. Secretary, J. P. Keenan, Milwaukee.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

WASHINGTON STATE GOOD ROADS ASSOCIATION.—Convention to be held at Spokane, Wash., November 18th, 19th, and 20th. Secretary, M. D. Lechey, Alaska Building, Seattle, Wash.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.

Volume 27. Toronto, October 1, 1914 Contents of this issue on page 3

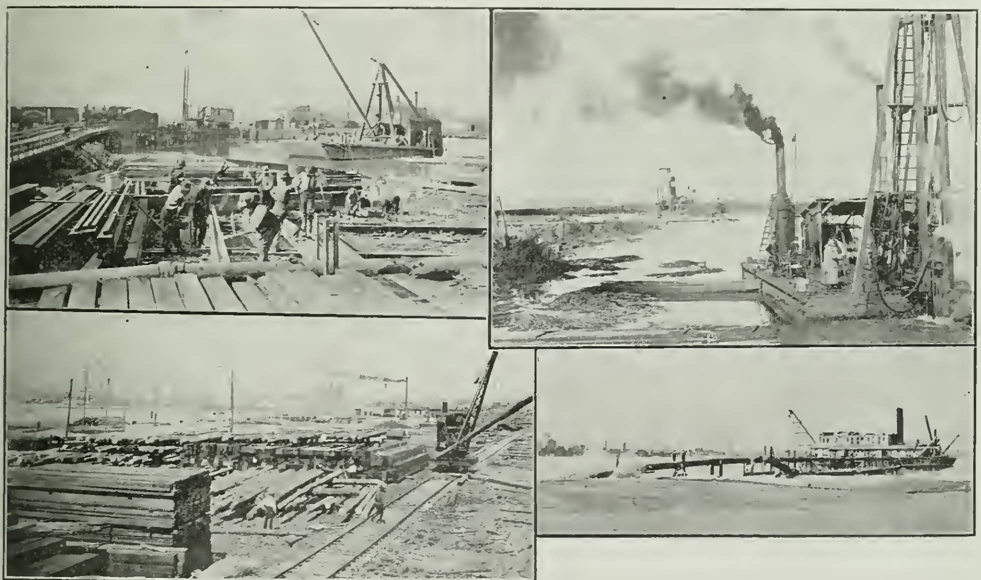
The Canadian Engineer

A weekly paper for engineers and engineering-contractors

TORONTO HARBOR AND WATERFRONT DEVELOPMENT

ENGINEERING FEATURES OF THE WORK AS OUTLINED IN THE 1913 REPORT OF THE TORONTO HARBOR COMMISSIONERS—SYNOPSIS ALSO OF 1914 ACTIVITIES.

THE report of the Toronto Harbor Commissioners covering the progress made during the year 1913 has just been issued. The general scheme of development was placed before our readers in *The Canadian Engineer* for November 21, 1912. A brief résumé of the project, the estimated cost of which was then stated to be $19,142,088, besides docks to cost five or six millions, is as follows: The construction of a modern harbor with a uniform depth of water capable of accommodating vessels up to 25 ft. draft; modern permanent docks on the central waterfront equipped with up-to-date freight sheds, warehouses and dock apparatus; large docks and industrial district at the foot of Cherry Street, with proper freight shed and warehouse equipment, etc.; a similar dock development at the foot of Bathurst Street, west of the central development; an industrial area of 1,000 acres east of Cherry Street, capable of accommodating factory buildings with a value of $30,000,000 and producing a ground rent revenue of $500,000 per year; a ship channel 6,800 ft. long, 400 ft. wide and 24 ft. deep with a turning basin 1,000 ft. square at its east end, serving the industrial district and the eastern portion of the city generally, and equipped with



Views of 1913 Activities. Preparing Sheet Piling for the North Slip Retaining Wall; Commencing the Construction of the Ship Channel; View of Pile Yard; Harbor Deepening and Reclamation Work.

three miles of dockage; a dock area on the western face of this industrial division to provide an additional three miles of dockage; a new lake-front park, drive and waterway extending from the Eastern Channel to the foot of Woodbine Avenue and containing 352 acres, protected by a breakwater nearly four miles in length; a protected waterway 1 ¼ miles long, averaging 600 ft. in width, from Woodbine Avenue to the city limits on the east; 352 acres of additional park area on Toronto Island and new park areas from Bathurst Street to the Humber River to the extent of 190 acres and fronting on a protected waterway

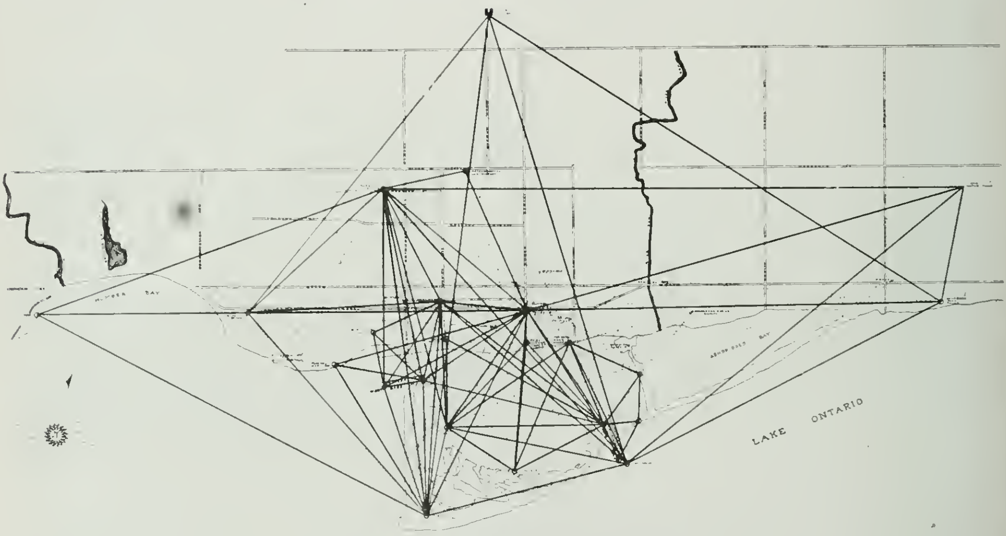
with a minimum width of 300 ft., separated from the lake by a breakwater; a bathing beach 1⅓ miles in length from Sunnyside to the Humber on a similar beach 4¼ miles in length from the Eastern Channel to Victoria Park; a boulevard system of driveways, etc., 11 miles in length across the waterfront; a protected waterway 12 miles in length with provision inside the breakwaters for equatic clubs; promenades, recreation piers, public playgrounds, etc., etc.

Preliminary plans were completed with the close of the year 1912. The general plans, providing for the development of the harbor and of the harbor industrial district, as well as for the general improvement of the outer waterfront and the construction of breakwaters for the purpose of protecting the waterfront east and west of the inner harbor were approved by the Toronto City Council and by the Federal Government in June, 1913. During the year substantial progress was made in the preparation of detailed working plans and a completion of arrangements for letting contracts and starting work. Dredging operations for the filling of the industrial district and the reclaiming of other lands were let by contract to the Canadian Stewart Company, Toronto, the minimum price being $3,950,000, with an option to increase the amount of dredging at the same unit price per cubic yard up to a total of $6,320,000. A contract was also let by the Government to the same company for the construction of a breakwater extending from Woodbine Avenue to the Eastern Channel and another extending from the Western Channel to the Humber River, together with the construction and dredging of the ship channel in the industrial district, the total contract calling for an expenditure of $5,371,372.17. The Government also undertook the construction of lift bridges across the eastern and western entrances to the harbor and across the ship channel in the industrial district, but contracts for this portion of the work have not yet been let.

Another important event of 1913, which is more or less inter-connected with the progress of the harbor work, was the agreement between the city, the Harbor Commissioners and the various railways for the separation of railway and highway grades across the Toronto waterfront by means of a viaduct. On July 29, 1913, an agreement was finally executed and confirmed by the Board of Railway Commissioners for Canada. This agreement affected the Harbor Commission in the matter of property rights along the waterfront.

During 1913 the hydrographic and land surveys commenced in the previous year were completed with the exception of the detailed survey of Toronto Island. This latter work was held over for 1914. A very important undertaking of the Surveys Department consisted of a careful delineation of the amount of land owned by the Commissioners; *i.e.*, property surveys. For the most part, these lands are water lots with their northerly limit an old shore line whose exact position in most cases had never been thoroughly surveyed or tied in. This, combined with the fact that very few lines could be ranged or chained, being mostly over water or marsh, but that all the field work had to be done by offsets or by traverse, engendered a multiplicity of calculation with an attending greatly increased chance of error, made the progress of the work somewhat slow. Permanent monuments were placed to define the ground limits of the Commission. These monuments consist of 3-inch iron pipe filled with concrete, in the top of which is embedded a 5-inch hexagonal plate bearing a serial number and the name "Toronto Harbor Commissioners." The pipes range from 18 feet long in marsh to 3 feet in length where bolted to bare rock. In general, the tops are level with the grade adopted for the waterfront improvements.

During the year, also, a valuable series of water tables and fluctuations of Lake Ontario since 1853 was compiled, as a result of which the elevation of the zero of the Harbor Commissioner's gauge was found to be 245 ft. above mean sea level of New York. The determination of this elevation was followed by the placing of a comprehensive set of levels and bench marks across the



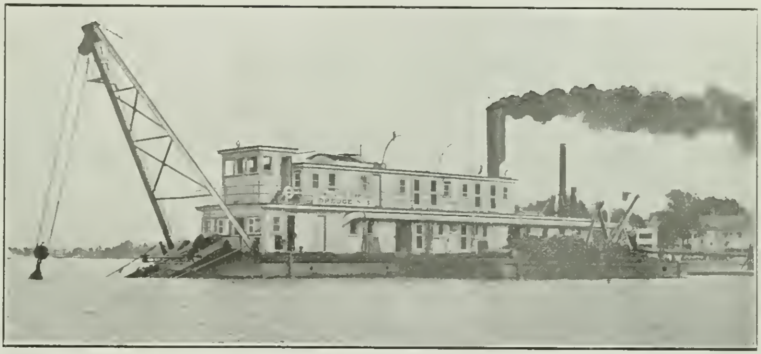
Triangle Net of Main Triangulation.

waterfront. During 1912 the Surveys Department had been seriously handicapped by the extreme lack all along the waterfront of bench marks referred to any single datum. The Department of Works of the city had under way at that time the establishment of bench marks throughout the city, but the number they proposed to establish in the region of the proposed work was insufficient. So, early in 1913, the Surveys Department of the Commission set about to establish bench marks that would be readily available when needed during the development of the waterfront. Sea level at New York Harbor was adopted for the datum, the plane of reference being, as stated, found to be 245.00 feet above such datum.

The method of field work did not involve the methods of precise levelling as used in connection with primary geodetic surveys, but only one of sufficient precision as to render the levels more than adequately accurate for any engineering work which might require them. An engineer's Wye level and a self-reading Chesterman rod were used, great care being taken to equalize the back and foresights. For this purpose, as well as to determine more exactly the rod reading, the reading of all three cross wires were taken. Benches were set about one-quarter of a mile apart and four lines of levels, forward and back and forward and back, run the same day and under the same conditions between consecutive benches, different turning, and set-up points being chosen in every instance. The arithmetic mean of these four differences of elevation was taken as the true instrumental difference in elevation between benches.

At 7 p.m. on Wednesday, July 9th, 1913, an evening of absolute calm, the whole Survey's staff were strung out along the entire waterfront from the Humber to Balmy Beach in thirteen locations and exactly at that hour nails were driven into convenient piles or cribs at the exact level of the water. The water lay dead calm, and there was no hesitation in assuming it a level plane. The elevations of these nails were subsequently tied each by four lines of levels to the nearest benches—in no case more than four hundred feet away—including a connection to the initial bench of the level net. On the assumption that while any two adjacent nails might have a difference of elevation, of such as much as 0.03 of a foot (the maximum sum of the personal errors of the two observers probable), yet this difference in elevation could not be exceeded though the observers were stationed at the extreme limit of the waterfront 10 miles apart. In other words, no adjustment was made to the instrumental elevations on the authority of a single water transfer, but only on the evidence of three or four in series. The level net was closed on the city bench marks. No weight was given to the elevations attached to these bench marks in the adjustment of the net, but on the completion of the adjustment, the elevation found for them by this department differed in no case more than a few hundredths of a foot for the elevation obtained for them by the Department of works.

An extensive precise triangulation was proceeded with and completed in December, affording a means of measurement with the transit or sextant of the angles between any three prominent points on the skyline of the city to determine the absolute position of any point. All angles were read 12 times around the circle, bringing the resultant measured angle within a probable exactitude of at least 2 seconds of arc in the harbor. A comprehensive survey was also made locating all intake pipes, sewer outfalls, drains and conduits along the entire waterfront; and another of the northwestern portion of the industrial district showing all existing structures, power lines, water mains, etc. Survey work was executed to facilitate future construction work, such as for the accurate and speedy laying out of boundary lines and locations of the various works. Extensive hydrographic surveys were also made in connection with the contract dredging and some 8,000 soundings, together with over 200 borings, were taken to obtain the nature of the material and the amount available at various depths. After these were effected detailed plans were prepared and tenders called for. The Canadian Stewart Company was awarded the contract at $19\frac{3}{4}$ cents per cubic yard, which, when the cost of supervision is added, will bring the cost to the Commissioners to practically 22 cents per cubic yard. The preliminary estimate of the engineering department averaged 21.99 cents per cubic yard.

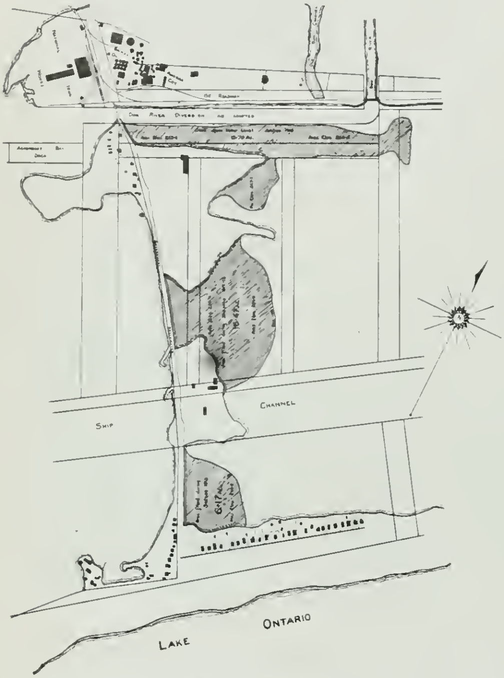


Harbor Commissioners' Hydraulic Dredge No. 3.

The construction department, in addition to general maintenance of all waterfront properties of the Commission, carried out the supervision of the construction of the Ashbridge's Bay docks, the sea wall from Dufferin Street westerly, the trestle across Keating's Channel to carry temporary tracks into the industrial district, the foundations of the Parkdale Canoe Club's new club house, the dredging of Point Anne Quarry slip and the complete supervision of the dredging equipment of the Commissioners. During the year Dredge No. 1 reclaimed for the city some 3.23 acres south of Hanlan's Point. Dredges Nos. 2 and 3 reclaimed to an average elevation of 250, 16.47 acres; to an average elevation of 249.5, 6.1 acres; to an average elevation of 248.5, 15.79 acres, or a total of practically 40 acres, in the industrial district.

The main work of the designing department consisted of details and final studies in connection with the construction of the government portion of the work; *i.e.*, the eastern and western sea walls, the ship channel, the marginal area, and the northern slip. In addition, detailed

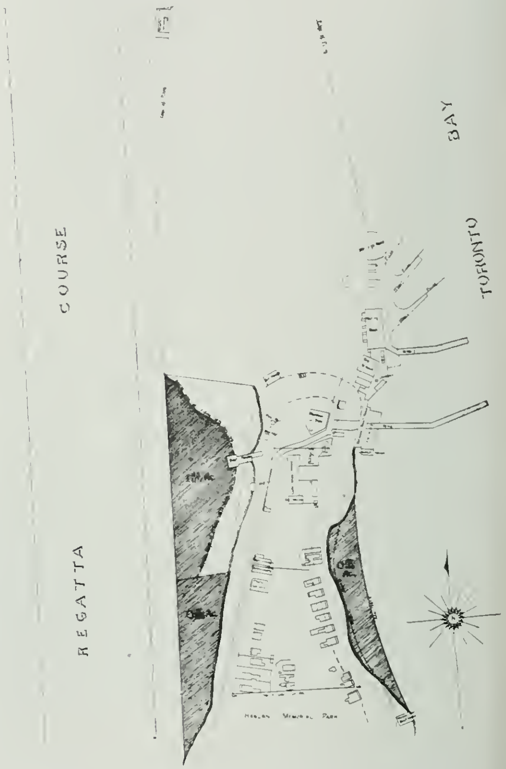
studies were made of the various types of bridges to ascertain those best suited for use over the channels. Over $6,000,000 worth of work was designed by the department for 1913, for which over 5½ million dollars worth of work was let before the end of the year. Detailed plans, specifications and estimates were prepared in connection with the work to be undertaken by the Government, and by the Commissioners, for over $11,000,000 worth of work, of which over $9,000,000 worth was contracted for before the end of the year. The entire scheme is being carried out under the direction of the Toronto Harbor Commission, consisting of L. H. Clarke, Chairman; R. S. Gourlay, T. L. Church, R. Home Smith and F. S. Spence. The Commission holds a Dominion charter with extensive powers in the development and management of the waterfront and harbor. To it the city has deeded its waterfront holdings (85% of the entire frontage) and its right to the marshy sections that are being filled in. Mr. E. L. Cousins is chief engineer to the Commission. His assistant engineers include Mr. J. R. Wainwright, in charge of designing and Mr. N. D. Wilson in charge of surveys. Mr. A. C. Mitchell is superintendent of construction. The consulting engineer of the Commission is Mr. J. G. Sing, Toronto.



Property Reclaimed in Eastern Section by the Harbor Commission During 1913.

While the foregoing notes relate to 1913 operations only, as outlined in the annual report, it will be of interest to observe that during the present year the engineering department of the Commission has been very actively engaged in the furtherance of the work. The foundations for the new building for the Parkdale Canoe Club have been completed. The previous building was burned in February, 1913. Its location was directly in line with the improvements planned by the Commission, and the negotiations between the two organizations included the erection of foundations, by the Commission, on a different site.

The construction of the Don River diversion, a contract amounting to $171,000, and being executed departmentally, will be finished by November 1st of this year. The Commission's dredges have all been actively engaged in reclamation work throughout the harbor during the entire season. The dredge "Shuniah," of the Canadian Stewart Company, has been similarly engaged in reclamation work since July. It is expected that the "Cyclone," one of the new 24-in. dredges being built by the Polson Iron Works for this company, and nearing completion, will commence work late this fall. Its sister dredge, "Tornado," will be completed this winter and ready for operations in the spring.



Reclamation Work During 1913 at Hanlan's Point, by the Commissioner's Hydraulic Dredges.

A length of about 1,600 ft. of the western breakwater extending from the Humber River westward, one of the Government contracts, is already in place. About 8,000 ft. of dock-work is under construction, belonging to a Government contract on the eastern section of the bay. This is in connection with work on the marginal way and ship channel, and on which considerable progress has been made.

ROAD SURFACING COSTS IN NIAGARA FALLS PARK.

SOME interesting cost data was gathered by Mr. John H. Jackson, Superintendent of Queen Victoria Niagara Falls Park, in connection with a five-mile stretch of macadamizing between Chippawa and Bridgeburg, Ont. This work was included in the 1913 parking program of the Commissioners. The following figures are from the 28th annual report, just published.

Part of the mileage under consideration required a light resurfacing, and another portion required the entire reconstruction of the top courses. For these two operations the following figures will show in detail the amounts that were spent per square yard:

The Light Resurfacing Water Bound Macadam Roadway.

Time—August 5th, 1913, to October 21st, 1913.
Location—Boulevard roadway from Slater's Dock, south.
Average length of haul—3.4 miles from M.C.R. siding, Chippawa.
Area treated—Length 14,625 ft. = 2.77 miles; width 18 ft. = 29,250 square yards.

Labor:	Total.	Per sq. yd.
Loading 2-in. stone and screenings	$ 232.56	8 cts.
Hauling	442.95	1.51
Pumping and watering	45.29	.15
Repairing roadway	275.18	.94
Rolling and spiking	97.29	.33
	$1,093.27	3.37 cts.
Material:		
2-in. stone—205.5 tons at $1.25	$ 256.88	.88 cts.
Screenings—150.2 tons at $1.00	150.20	.51
	$ 407.08	1.39 cts.
Summary:		
Labor	$1,093.27	3.73 cts.
Materials	407.08	1.39
	$1,500.35	5.12 cts.

Remarks:

297 cubic yards of stone and screenings were placed on 29,250 square yards.
1 cubic yard of stone and screenings was placed on 98.5 square yards.
Ratio of 2-in. stone to screenings used—1 to .731.
Ton-mile cost of hauling materials—36.2 cts.

Wage Rates:

Teams	55c. per hour
Laborers	22c. "
Foremen	30c. "
Cost per mile	$540.00

The Heavy Resurfacing Water Bound Macadam Roadway.

Time—August 1st, 1913, to December 15th, 1913.
Location—Boulevard roadway, from Black Creek, north.
Average length of haul—1.98 miles from Black Creek siding.
Area treated—Length 14,467 ft. = 2.74 miles; width 18 ft. = 28,934 square yards.

Labor:	Total.	Per sq. yd.
Loading 2 in. stone and screenings	$ 521.00	1.8 cts.
Hauling	1,509.00	5.2
Pumping and watering	215.00	.8
Repairing roadway	547.00	1.9
Rolling and spiking	425.00	1.5
	$3,217.00	11.2 cts.
Material:		
2-in. stone—750 tons at $1.10	$ 825.00	2.9 cts.
Screenings—324½ tons at $1.10	357.00	1.2
	$1,182.00	4.1 cts.
Summary:		
Labor	$3,217.00	11.2 cts.
Materials	1,182.00	4.1
	$4,399.00	15.3 cts.

Remarks:

895.4 cubic yards of stone and screenings were placed on 28,934 square yards.
1 cubic yard of stone and screenings was placed on 32.3 square yards.
Ratio of 2-in. stone to screenings used—1 to .433.
Ton-mile cost of loading and hauling materials—32.3 cts.

Wage Rates:

Teams	45c. per hour
Laborers	20c. "
Foremen	30c. "
Cost per mile	$1,600.00

At Queen Victoria Park rates for teams, .55c., and men .22c., the above ton-mile cost would be 38.4c.

In connection with the scarifying and re-crowning of this section of roadway a bituminous top was laid on a 2¾-mile length, and the following figures show the cost of different operations in connection therewith:

Tarvia "A" and ½-inch Stone Surfacing.

Time—September 2nd to October 16th, 1913.
Location—Boulevard roadway, vicinity of Usher's Creek.
Length of haul—3.4 miles.
Area treated—Length 14,625 ft. = 2.77 miles; width 18 ft. — 0 in. = 263,250 square feet = 29,250 square yards.
Depth—½ inch.

Labor Cost:	Total.	Per sq. yd.
Loading, hauling and placing stone	$ 861.05	2.90 cts.
Loading, hauling and placing tarvia	353.71	1.19
Placing and removing plant	56.50	.19
	$1,271.24	4.28 cts.
Material Cost:		
½-in. stone—487.5 tons at $1.30	$ 633.75	2.14 cts.
Tarvia "A"—14,307 gallons at 10c.	1,430.70	5.58
Freight, $188.35; demurrage, $32	220.35	
Soft coal for heating and operating roller	88.90	.30
	$2,373.70	8.02 cts.
Summary:		
Labor	$1,271.24	4.28 cts.
Materials	2,373.70	8.02
	$3,644.94	12.30 cts.

2.77 miles cost	$3,644.94
1 mile cost	1,300.00
1 square yard cost	12.30

This was a carpet treatment undertaken with refined tar, known as Tarvia "A." The material was shipped in tank cars to the nearest railway siding, and heated by means of a steam boiler to a temperature of 100° F. when it was forced by steam pressure into the distributing apparatus, and then hauled to the site of the work where it was attached to the steam roller. Connection was here

made with the boiler and the material further heated to a temperature of between 175° and 200° F. Steam pressure at thirty-five pounds was then applied to spray it on to the road surface. The apparatus used is supplied at the rear with nozzles so constructed that upon the application of pressure the hot material is forced to the surface of the road in a fine spray. The heated tar penetrates the top surface, and the remainder is then absorbed by means of one-half inch stone chips in the proportion of one cubic yard over about sixty-five square yards of surface giving a depth of stone and tar equal to a little over one-half inch. The quantity of bituminous material for this treatment was one-half gallon to the square yard, and as indicated the total cost including labor was 12.3c. per square yard, or about $1,300 per mile for an eighteen-foot roadway. It is estimated that the only cost of upkeep to this surface will be an annual tar spraying of about one-eighth of a gallon per square yard at a cost of between three and four cents per square yard, or about $320 per mile for an eighteen-foot roadway.

In comparison with the heavy water bound macadam resurfacing it is interesting to note the details of figures for extra heavy resurfacing with a chemical binder. The following figures show the details of cost for a Rocmac resurfacing upon the main driveway of the park where the road metal was four inches:

Rocmac Resurfacing at Rambler's Rest.

Time—May, 1913.
Location—Main driveway, opposite Rambler's Rest loop.
Length of haul—3,400 ft. = .644 mile, (from Victoria Park siding).
Area treated—Length 370 ft.; width 21 ft. = 7,760 square feet = 863 square yards.
Depth removed—4 inches.
Material removed—370 ft. x 21 ft. x 4 in. = 2,590 cubic feet = 96 cubic yards (in place).

Labor Cost:	Total.	Per sq. yd.
Removing old surface (96 cu. yds.)	$ 97.20	11.26 cts.
Hauling 144 cu. yds. of stone and screenings from Victoria Park Station	119.08	13.80
Rolling	28.00	3.25
Resurfacing	63.16	7.31
Foreman	60.20	6.97
	$367.64	42.59 cts.

Material Cost:	Total.	Per sq. yd.
2-in. stone, 114 cubic yards—136.8 tons at $1.25	$171.00	19.82 cts.
Screenings, 30 cubic yards—36 tons at $1.00	36.00	4.17
Rocmac solution, 374 gallons at 45c.	168.30	19.50
	$375.30	43.49 cts.

Summary:	Total.	Per sq. yd.
Labor	$367.64	42.59 cts.
Material	375.30	43.49
	$742.94	86.08 cts.

The American Society for Testing Materials has added to its specifications for reinforcing steel rolled from billets, an intermediate grade between the structural and hard grades. This new grade is to have a yield point of 40,000 lbs., and an ultimate tensile strength of from 70,000 to 85,000 lbs.

INSTALLATION OF TRANSFORMERS FOR TORONTO POWER COMPANY.

An installation of considerable inportance has been made recently by the Toronto Power Company in the way of six kv.a, single-phase transformers at the Niagara Falls step-up station, and six 5,500 kv.a. similar single-phase units at the Toronto terminal station of the company. This installation is of special interest in view of the fact that the new transformers were especially designed and constructed to fit the existing transformer pockets which were laid out originally for lower voltage units of less than half the present capacity. The original transformers were single-phase, water-cooled units designed for 2,670 kv.a., 60,000 volts, at the generating station and for 2,400 kv.a., 55,000 volts at the terminal station. These transformers were of the familiar oval type. The new transformers are single-phase, water-cooled units of 6,000 kv.a. unit capacity at the Niagara station, designed for 86,500 volts, and similar units of 5,500 kv.a. each at the Toronto terminal station, designed for 76,100 volts.

They were built by the Canadian General Electric Company at its Peterborough factory and are assembled in square or slightly rectangular boiler plate tanks, having all seams oxy-acetylene welded. The flat sides of the tanks are braced by "T" iron straps for mechanical stability. The transformer tanks were required to stand a 26-inch vacuum test at the factory before acceptance. The usual heavy castings have been replaced in this design by channel core plates riveted together in pairs. A space is left between the channels which is arranged to come directly over a vertical duct in the iron, allowing a free circulation of oil up through the centre of the iron. These features and others which it is understood have been adopted as standard by the manufacturers of these transformers account for the remarkable increase in capacity per unit space over the original transformers in the same stations. The same factors are reflected in the gradual tendency toward smaller dimensions and lighter weights in power transformers making use of rolled steel instead of heavy castings.

STEEL RAILROAD TIES.

Steel railroad ties are being extensively used in Switzerland. At present 65 per cent. of the Federal Railways employ them. They have the form or profile of a trough into which shape they are rolled at the mills. The ends are bent down, the profile of the trough being thus closed. Holes are provided for the attachment of the rails by means of clamp plates and no tieplates are used under the rails. The weight of the trough profile is 55.47 lbs. per meter and the ties complete, with holes bored, weigh 159.84 lbs. each. According to the requirements of the Federal Railways the steel in these ties must have a tensile strength of about 59,000 to 64,000 lbs. per square inch and an entire trough piece shall admit of being bent together on its back without showing any breaking fissures.

The Gun-crete Company, of Chicago, informs us that, taking effect September 1st, 1914, they have purchased all the rights, titles, contracts and interests of the Cement-Gun Construction Company, and have also taken over the construction department of the General Cement-Gun Company. In future, the combined business will be conducted under the firm name of Cement-Gun Construction Company, with offices at 914 So. Michigan Avenue. The officers of the company are Carl Webber, C.E., president; John V. Schaefer, M.E., secretary and treasurer; C. L. Dewey, construction manager.

LOCK GATE LIFTER FOR TRENT CANAL.

THE accompanying illustrations show the steel pontoon dock that was recently built for the Department of Railways and Canals for service on the Trent Canal, by M. Beatty and Sons, Limited, of Welland. It was designed and built to lift and place into position the lock gates, and its capacity of 50 tons and clearance of 37 feet above the dock will enable it to step

Fig. 1.—The Gate Lifter Just After Completion, Showing the Top of Derrick Raised.

any of the mitred gates throughout the entire length of the Trent Canal. The general design comprises a structural steel collapsible derrick mounted on a steel pontoon, with separate steam engines for each operation.

The pontoon supporting the derrick is made of steel plating with extra strong steel frame work, there being two longitudinal and three transverse trusses, so as to provide for the severe loads it will have to bear. The hull is constructed with rounded bilges and each end has a rake of 45 degrees. The length is 55 feet, beam 27½ feet, depth 9 feet.

The derrick is built of structural steel in two units. When in working position, the derrick is erect, as shown

Fig. 2.—Gate Lifter with Top of Derrick Lowered for Passing Under Overhead Bridges.

in Fig. 1. In transporting the lifter from one lock to another, the upper part of derrick is lowered where necessary, as per Fig. 2, which allows of its passage under overhead bridges along the canal. The operation of raising and lowering the derrick is performed by a 6 x 6-in. double cylinder engine mounted on one of the back legs. Two swivel hook padlocks are suspended, one from each overhanging top of front legs of derrick, each carrying 8 parts of ⅞-in. steel cable. The main engine has 9 x 9-in. double cylinders, double drums and is link reverse. The operating levers are brought to one position for the convenience of the engineer.

The pontoon is kept on an even keel by two movable ballast cars under deck. Each car is moved by a steel screw operated by independent 6 x 6-in. reversing engine. These engines are controlled by pendulum governors, automatically shifting the ballast to the proper position to put the pontoon on an even keel, whether it is under load or light, with the derrick upright or folded. In addition to the automatic control, the ballast car engines can be operated from the engine room above deck. Dial indicators are provided to show the position of the ballast cars at all times.

The machine has stepped to date the gates for Locks No. 1, 2, 3, 4, 5 and 6 of the Ontario-Rice Lake division of the Trent Canal and in operation has met all expectations. The total time for stepping each leaf from picking up in water to releasing in gate recess varied from twenty to forty minutes, according as an upper or lower gate

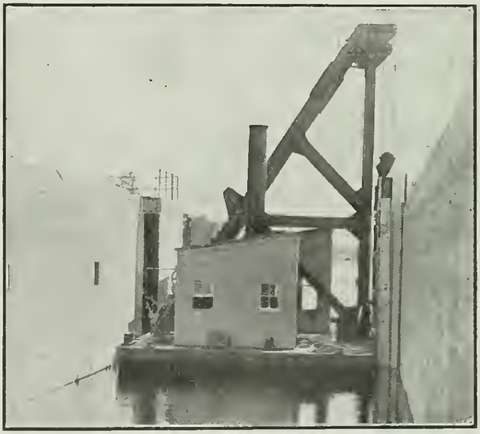


Fig. 3.—Gate Lifter Placing a Leaf in the Gate Recess of Lock No. 4, Rice Lake Division, Trent Canal.

leaf was handled respectively. At Lock No. 3 the lower gates are 37 feet high over timbers and these represent the heaviest gates the lifter is designed to handle. A view is shown in Fig. 3 of the gate lifter in the operation of stepping a gate.

SLAG IN RAILWAY BALLAST.

Slag is very largely used as railway ballast in the district of Lorraine, Germany. About 250 miles, or two-thirds of the total mileage, are ballasted more or less completely with that material. It is used chiefly on roads that have been constructed or reballasted in recent years and especially on the roads over which traffic is heavy. On smaller, less used lines where the traffic is light, gravel or whatever suitable material is at hand, is used. Slag costs about 14½ cents per cu. yd. at the furnace. It is regarded as economical ballast within a radius of 15 to 30 miles, but cannot compete with rock at a greater distance than that on account of the cost of transportation, except, of course, in places where no suitable rock ballast is to be found. It is said that the slag is far superior to gravel as ballast and that it is equal to the best variety of rock.

REINFORCED CONCRETE DOCKS IN NORTH AMERICA.

In *The Canadian Engineer* for August 27th, 1914, an article appears dealing with the application in England of reinforced concrete to dock construction. The following article supplements the former by outlining the extent of similar construction in North America, with special reference to such works in the United States. We are indebted to the same source for this information, viz., a paper by Harrison S. Taft, read before the American Society of Civil Engineers on May 20, 1914, which paper reviews the reinforced concrete dock construction of the world.

In recording what has been accomplished in the construction of reinforced concrete docks in North America, including Porto Rico, Cuba, the Canal Zone, and Canada, such undertakings are so few and of such recent date, compared with those in European countries, that the art of building reinforced concrete docks there may be said to be hardly beyond its infancy, especially as regards out-and-out docks or piers, as the American usually understands the word, viz., long structures running out from the shore in such a way that vessels can lie on each side. Unfortunately, it will be necessary to make note of some failures among North American concrete docks.

Atlantic Coast.

Boston.—The first concrete dock built in Boston Harbor has perhaps caused more discussion as to the feasibility of using concrete in sea water than any other American structure of this type, and, therefore, is far-famed in itself. This dock, or pier, was built at the Charleston Navy Yard about 14 years ago. The first section, consisting of a long, straight wall, was built in 1899-1900, without any resort to a cofferdam. The other two sections, consisting of plain reinforced arches, 20 ft. wide, with spandrel walls, were constructed in 1901, the space between the two walls being filled with earth and stone. The first section was built of 1:2:3 concrete throughout, and it was all placed in the wet, with an open-top bucket. The second and third sections were of different mixtures, the main body being of 1:3:6 concrete, the outer 2 ft. consisting of a 1:2:4 mixture, and the whole exposed surface was faced with 3 in. of 1:1 mortar. In these two sections the concrete was placed very dry, as was the practise at that time.

During 1913 one of the Boston public docks, Pier No. 5, was partly rebuilt in concrete. This dock consisted of a timber platform deck, 50 ft. wide and 1,150 ft. long, on each side of a solid earth fill. The new wooden piles needed were driven, and all the piles, new and old, were cut off at mean high water and capped with a deep reinforced concrete beam running athwart the piles, in the way of curtain-walls. These curtain-walls support two longitudinal reinforced concrete beams, the third or inner beam resting on the earth retaining wall. There are also two additional concrete beams under the track along the outer face of the dock, with special supporting piles. On top of the curtain-wall and longitudinal girders is laid a reinforced concrete floor-slab with a 2-in. bitulithic top. Wooden longitudinal tie members are run from top of pile to top of pile under the concrete curtain-walls, the whole timber structure being well braced with piles and wooden ties. To provide against accident from disintegration of the lower part of the curtain-walls, due to frost action or other cause, cast-iron columns, 30 in. long, are attached to the top of the piles and made integral with the curtain-walls, thus guarding against weakness in the concrete, rather than in the piles, as done in other harbors.

New York Harbor and New Jersey Coast.—A reinforced concrete dock of an experimental nature was constructed at Ellis Island, New York Harbor, in 1911. It is a rather small structure, 30 ft. wide and 50 ft. long, resting on thirty-six driven concrete piles 18 in. square. The piles were made of different mixtures, for experiment purposes, and various kinds of waterproofing were used in order to determine their efficiency under the same conditions. This was the first complete concrete pile and deck dock built in New York Harbor.

During the past seven years a semi-concrete type of dock has been under development in New York Harbor, viz., wooden piling, wooden caps, and concrete decking. In one dock, on the New Jersey side of the Hudson, the caps on top of the piles are also of concrete. In the final type, as worked out by the Department of Docks and Ferries,* the concrete slab rests directly on wooden caps secured to the tops of the wooden piles, a genuine flat slab between bents, the entire timber floor system being wholly eliminated. At present some 25 or 30 semi-concrete docks have been built on this system in New York Harbor. It has been stated authoritatively that they have proved a great success.

In building two semi-concrete docks at the Brooklyn Navy Yard a few years ago, the objectionable features of docks of the foregoing type—viz., part of the wooden pilings and bracing exposed to wet and dry conditions between low water and the decking, and the wooden cap as an additional temporary item helping to support a permanent structure—were eliminated. In the two Navy Yard docks the wooden piles were cut off a little above low water and capped with a wooden grillage. Pre-moulded concrete columns, mixed with waterproofing compounds, were set on and dovetailed into the caps, and a concrete girder-beam and deck-slab system was worked over the tops of the columns. The wearing surface consists of a creosoted wooden block pavement. Down each side of the dock there is a standard-gauge railroad.

A small concrete dock was constructed at Glen Cove as a yacht-landing, in the winter of 1909-10. It consists of eight reinforced concrete rock-filled caissons, supporting an overhead footbridge, the total length of the pier being about 330 ft.

Long Branch.—At Long Branch a Hennebique type of concrete pile dock was constructed in 1911, running some 848 ft. out into the Atlantic Ocean, as a boat landing and recreation pier. At present the pier is only 75 ft. wide, except for an 80-ft. length at its outer end, where its width is 150 ft., the intention being to make the whole pier of that width at some future time. The deck is 22 ft. above low water. The piles are 16 ft. from centre to centre longitudinally, but 20 ft. from centre to centre across the pier, except the outer two rows, which are 15 ft. from centre to centre. Most of the piles are of hollow cross-section, 22 in. external diameter, 13 in. internal diameter; the penetration was about 22 ft. To provide sufficient impermeability, the shells of the piles were made of $1:1\frac{1}{2}:3$ concrete, the fill being of a weaker mixture. Apparently, no cross-bracing system was used, the outer end of the pier being stiffened laterally by inclined bracing piles at regular intervals.

Atlantic City.—At Atlantic City the famous steel pier was widened and protected in 1906 by the use of concrete. The original pier was founded on steel-pipe piles resting

*Transactions, Am. Soc. C.E., Vol. LXXVII., p. 503

on cast-iron disks, a type of construction quite common during the last part of the 19th century. The pier extends out into the Atlantic Ocean a total length of 1,600 ft. In rebuilding the pier all the original metal work was encased in concrete and the pier was widened on both sides, 12-in. and 25-in. reinforced concrete piles, with enlarged footings, being used. The smaller piles were pre-moulded vertically, on a small platform, each pile at its final location. After hardening sufficiently they were lifted off their platform and jetted into place through from 8 to 14 ft. of sand. The larger piles were given a penetration of 16 ft. The lower 12 ft. of these piles were pre-moulded on a platform, a water-tight iron casing was secured to the upper end, and the whole was jetted into place. The dry caisson was then filled with concrete up to the proper level, the maximum total length of the 25-in. piles being 52 ft. In protecting the original piles, concrete shells were cast around them, with sufficient interior clearance, and the space was afterward filled with grout.

After the concrete work of this structure had been in the sea water for 6 months, the piles became coated with a sort of gelatinous matter which seemed to act as a most excellent protective coating against any deterioration. The same peculiar action has also been noticed in California.

Although not exactly a dock, it is of interest to note the concrete pile Boardwalk at Atlantic City. Not only is it necessary to guard against dry and wet conditions at such resorts, but the fine sands act like a sand-blast when driven like snow before the wind. In 1908 part of the old wooden structure was rebuilt with 16-in. concrete piles, supporting a concrete cap, and that in turn carried the wooden decking.

Baltimore.—It is perhaps at Baltimore that the most extensive reinforced concrete docks on the Atlantic seaboard have been built. Although the water in Baltimore Harbor may not have the same density of salt as in ports nearer the sea, these docks, thus far, have shown no sign of deterioration, though at times subject to frost action. Three of these piers are of a back-filled concrete bulkhead type, and are not docks resting on piles. Pier No. 4 is 978 ft. long and 220 ft. wide; Pier No. 5 is 1,245 ft. long and 200 ft. wide at the shore end, but 243 ft. wide at the water end; Pier No. 6 is 1,456 ft. long and 93 ft. wide at the shore end, but 212 ft. wide at the water end; all were built in 1908.

In general, these three docks consist of a series of oval-shaped concrete cylinders 25 ft. apart along the face of the docks, and sunk to about 25 ft. below low water. Along the face of the cylinders, and just above high water, there is a concrete-encased iron girder, tied back to a deadman some 28 ft. in the rear of each cylinder. A row of concrete sheet-piling was driven back of the girders to form a vertical retaining wall, the upper ends of the sheet-piling bearing against the girder, and the lower ends being driven into the muddy bottom. A horizontal box-girder encased in concrete runs along the upper face of the dock, supporting the outer edge of the concrete curb slab, on which are laid the paving blocks. The cylinders are tied together in certain cases by ties extending entirely across the docks. The face of each dock is protected by wooden fender-piles, 8 ft. apart. Another concrete dock has been completed recently in Baltimore by the Harbor Commission, the details of which are lacking. In the same harbor is found a concrete bulkhead dock, built for a private corporation—a reinforced concrete sheet-piling structure capped with a concrete girder tied back to deadmen by reinforced concrete ties.

At Sparrows Point, near Baltimore, a reinforced concrete ore dock, 600 ft. long, was built in 1911. It consists of two parallel concrete walls, about 46 ft. apart, viz., (1) a sheet-pile bulkhead on the water-front capped by heavy concrete girders with a cantilevered shelf, as it were, on the outer face, running the full length of the bulkhead; (2) a heavy retaining wall in the rear, the two walls being tied together by reinforced concrete ties about 30 ft. apart. The back wall, resting on wooden piles, not only acts as a deadman for the outer wall, but affords a means for carrying one track of the large, heavy, ore unloading crane that straddles the filled-in space between the two walls, the front track of the crane running along the outer wall. The dock face is protected by a substantial system of fender-piles and wales with heavy helical car-springs at each buttress of the face wall.

Norfolk.—In constructing the Virginian Railway Coaling Terminal, at Sewells Point, in 1907, it was not practical to carry the massive steel superstructure on creosoted piles. In place thereof groups of wooden piles were driven and cut off 1 ft. below the mud line. On top of these piles were built monolithic concrete piers, of pyramidal shape, to 4 ft. above high water. All the concrete work was done in the dry, inside a cofferdam. These piers are reported to be in as good condition as when first built.

Brunswick and Charleston.—Perhaps the most extensive development of concrete dock construction, combining concrete piles with wooden decking, is found at Brunswick, Ga., and at the U.S. Navy Yard, Charleston, S.C., built in 1906.

The Brunswick terminal consists of two piers, 500 and 900 ft. in length, respectively, and each is 140 ft. wide; there is also a coaling pier about 300 ft. long. The 16-in. bearing piles, of pre-moulded concrete, are 12 ft. from centre to centre each way. They are from 30 to 51 ft. in length, with the lower 10 ft. tapering to 8 in. The piles have a penetration of 40 ft. Their upper ends are corbeled out to support the double 8 by 16-in. wooden caps. The decking consists of 6 by 14-in. stringers and a 3-in. flooring. Each bent is well braced with creosoted wooden cross-bracing.

The Charleston Navy Yard dock is 60 ft. wide and 250 ft. long, and of the same type of construction as the Brunswick structures. The piles, 10 ft. from centre to centre each way, are 18 in. square, instead of 16 in. square, and have an 8-ft. taper to 12 in. square at their lower ends, thus giving a heavier structure than those at Brunswick. The test load on the Charleston dock was 30 tons per pile for 48 hours, though the specification required only 20 tons, or 400 lb. per sq. ft.

The outer row of piles in these docks consisted of three creosoted yellow pine sticks, two of which were driven on a batter; all were bolted together to afford sufficient protection to the dock in the form of a fender-pile system.

During the building of the Brunswick dock it was rammed by a large steamer. Although a number of the pine piles were broken, it has been stated that the concrete piles withstood the shock successfully.

Savannah.—A rather unique type of concrete dock was built at Savannah, 17 miles from the sea, in 1913. The design seems to contain many of the excellent features of the Ambursen dam. This dock consists of a series of pile bents athwart the dock supporting reinforced concrete brackets of triangular shape, the brackets in turn supporting a concrete deck-slab sloping down and toward the rear of the structure. This deck was afterward back-

filled and finished off with a suitable working face. The dock forms a water-front structure, and is protected by wooden fender-piles.

Jacksonville.—In the construction of a semi-concrete dock at Jacksonville, the Braxten concrete pile was used, with very satisfactory results. In another case the Ripley concrete-encased wooden pile was adopted.

Key West.—A reinforced concrete quay wall dock, 1,589 ft. long, was completed at the U.S. Navy Yard at Key West in 1912. The main wall consists of a series of pre-moulded concrete pile bents capped by a concrete girder and a deck-slab 40 ft. wide on top. From the inner edge of the deck-slab a sloping concrete apron runs down to the top of a row of sheet-piles which forms a retaining wall for the reclaimed land. The piles are from 16½ to 20 in. square, and vary from 25 to 60 ft. in length. The bents are 10 ft. apart, with the same spacing for the piles, each bent having six piles. The face of the dock is protected by a system of creosoted fender-piles placed midway between each bent.

Port Arthur.—A reinforced concrete pile-bent dock, 1,050 ft. long and 25 ft. wide, was constructed at Port Arthur, Tex., in 1911-12. In general, the piles are 16 in. square, 44 ft. long, and 5½ ft. from centre to centre. The pile bents, of five piles each, are about 23 ft. apart, and are capped with a reinforced concrete girder. Five concrete beams, running from bent to bent, and a 4½-in. concrete slab, form the deck structure. The dock is tied back to the concrete trestle built for carrying the railroad tracks in the rear of the dock. No provision is made for any spring or other device to take up the impact forces on the fender system, as it is believed that the wooden fender-piles will afford sufficient elasticity to prevent any injury to the dock from this source.

Cuba.—Two reinforced concrete docks, 620 and 670 ft. in length, respectively, and 160 ft. wide, were built in 1911-12 at Havana, the depth of the water varying from 12 to 40 ft. Each consists of a concrete floor-slab resting directly on concrete caps placed on top of clusters of from four to eighteen reinforced concrete piles, the clusters being about 23 ft. from centre to centre in each direction. The concrete piles, 18 and 20 in. square, were designed for a load of 32 tons each. The design of the floor slab would indicate a cantilever effect longitudinally between each row of longitudinal piling.

One of the railroad companies of Cuba, also, has built a reinforced concrete dock at Havana, for coaling purposes. The structure, which is subjected to very heavy loading, rests on Chenoweth concrete piling, and was but recently finished.

Haiti.—In constructing a reinforced concrete dock at Port au Prince, during 1913, the Ripley type of concrete wrapped wooden pile was adopted. This dock has a total length of 2,326 ft., varying in width from 24 to 60 ft. The piles are 10 ft. from centre to centre, longitudinally and transversely, and are capped by heavy concrete girders of rectangular section for the inshore end of the dock, otherwise by arched girders. The deck system consists of a series of reinforced concrete beams supporting the concrete deck-slab, built with a crown, in order to shed water. The dock is protected by a creosoted fender-pile system.

Panama and Canal Zone.—The United Fruit Company in 1909 built a combined reinforced concrete and wooden pile dock at Bocas del Toro, for the docking of fairly large steamers. The wooden piling is surrounded by a 4-in. concrete shell up to about 1 ft. above the high-water line. The piles are extended up to the deck as reinforced columns, with a concrete beam and deck-slab system. Up to the present time the dock is said to have given good results.

In the Canal Zone the U.S. Army Engineers have constructed a reinforced concrete dock, 706 ft. long and 55 ft. wide, for unloading timber. There are fifty-five concrete piers or columns, 8 ft. in diameter and about 80 ft. long arranged in two rows, 35 ft. from centre to centre across the dock, and 30 ft. from centre to centre longitudinally, and built in the form of hollow reinforced concrete sectional cylinders. After these cylinders had been sunk to bed-rock, they were filled with concrete, being reinforced vertically with eight rails. On top of the columns there is a concrete girder, deck-beam, slab system. The girders are about 5½ ft. deep, the beams about 4½ ft. deep, and the slab 6 in. thick. The railroad track runs over one row of columns. The floor system is designed for a load of 400 lb. per sq. ft., with a concentrated load of 105 tons over the track beams. The depth of water for a mean sea-level tide is 40 ft., the total fluctuation in the tide being 20 ft.

Two other concrete docks of extensive size are now in course of construction in the Canal Zone, with still more to follow.

Pacific Coast.

On the long stretch of our Pacific Coast, perhaps is found the greatest development of reinforced concrete dock construction in the United States. This section is making vast harbor improvements in anticipation of the opening of the Panama Canal.

San Diego.—At this most southern port on the California Coast an extensive reinforced concrete dock is now under construction. It consists of two parts, viz., the dock itself, 800 ft. long and 130 ft. wide, and a quay wall or bulkhead, 2,675 ft. long and 25 ft. wide. Wooden piles are driven into the soil and cut off "at any point between mean and low water and 18 ft. below city datum." Each of the 42-in. concrete columns encases one wooden pile and supports a system of structural deck-beams, a concrete slab covering the whole. The columns are 15 and 13 ft. 4 in. from centre to centre. The entire structure is protected by a wooden fender-pile system having the so-called San Francisco type of steel spring shock-absorbers.

San Pedro.—In connection with extensive port developments at San Pedro, a semi-reinforced concrete dock was recently completed in the outer harbor. It consists of pre-moulded concrete piles, 10 ft. from centre to centre in each bent, the bents being 16 ft. apart. The tops of these piles are corbeled out to support two 10 by 16-in. wooden caps, which in turn support the wooden floor joist and wooden decking. The piles are tied together with a wooden cross-bracing system above mean high tide. The structure is also stiffened against lateral blows on its face by inclined bracing piles. The wooden pile fender system has a car-spring to assist in taking up lateral forces. The dock is of the quay type, 48 ft. 6 in. in width, the total pier head frontage being 12,000 lin. ft. A railroad runs parallel to the inner edge on the inshore fill.

Redondo.—It is of interest to take note of the ocean pier at Redondo, Cal., though it is not a dock. It extends some 637 ft. out into the Pacific Ocean, and supports the intake pipe (for cooling purposes) of a power station. The pier consists of concrete pile bents, 20 ft. apart, each bent having four piles. As considerable surf runs at times under this pier, the outer bents have an extra outside pile driven with a batter of 2 in. per ft. The piles consist of a thin steel shell, 18 in. in diameter, closed at the lower end. After the steel cylinder had been driven to the

proper depth of penetration, the reinforcement was inserted and the cylinder was filled with concrete. The piles of each bent have a structural steel cap encased in concrete, with a system of diagonal bracing in a horizontal plane connecting the tops; there is also a longitudinal system of ties at the tops of the piles, above the reach of the water. This structure, as a whole, is said to possess considerable elasticity.

Long Beach, Cal.—In 1907 a concrete pile pier was built at Long Beach, extending some 1,300 ft. out into the ocean. The head of the pier is 100 ft. long and 300 ft. wide, the approach being 1,299 ft. long and 32 ft. wide. The deck is 30 ft. above mean low water, so as to be kept clear of the 24-ft. waves which at times roll in from the ocean. The piles and columns are 4½ ft. in diameter, and are arranged in bents. Under the head of the pier the bents and piles are 16 ft. from centre to centre. The approach bents are 20 ft. apart, with two columns each. The columns are sunk from 10 to 18 ft. into the sand, in order to be absolutely safe, as it is said that at times the undertow digs out the sand to a depth of 13 ft. The pile caps consist of steel I-beams, on top of which rest wooden stringers carrying a wooden decking.

Santa Monica.—At Santa Monica, an ocean pier, built in 1908-09, extends 1,600 ft. out into the ocean. It was built on driven concrete piling, ranging from 14 to 22 in. in diameter, in lengths up to 75 ft., with from 16 to 20 ft. penetration. Although the pier was built primarily to support the outfall sewer carrying the sewage effluent to a point far seaward, it is also used for recreation purposes. The pier is about 35 ft. wide at the deck line, with three platform spaces of 43 by 89 ft. at intermediate points and at the end. The bents are 20 ft. from centre to centre and consist of three piles, the piles being 13 ft. 6 in. from centre to centre. Each bent has a concrete cap on which rest the wooden joists covered with 2-in. planking, and the latter is covered with a 3-in. wire-mesh concrete slab, having the proper pitch to carry off the water. The bents are tied together by three longitudinal reinforced concrete tie-beams running from top of pile to top of pile. The piles are bulb-pointed.

San Francisco Bay.—Although the dock engineers of New York City have developed a type of semi-reinforced concrete dock, viz., a wooden pile structure supporting a concrete slab, especially adaptable to local conditions, the dock engineers of San Francisco have developed a type of full reinforced concrete dock based on wooden sub-piling, concrete column piers, steel or concrete deck-beams, and concrete floor slab, the concrete encasing the steel beams and the floor being made monolithic, with details varying to suit special conditions. Although the type as worked out presents no difficulty in the way of construction, outside of building the main columns, that part of the work has been done successfully, but with considerable difficulty. The mud line at the bottom of the bay is said to be approximately level, yet, at the outer ends of some of the piers there is a depth of only about 18 in. of mud over the rock; at the shore end, however, there is a depth of 35 ft. of mud. Piles can be driven to a rock bearing in some places, but it is impossible to use wooden piles throughout. Along a portion of the waterfront, where it is not possible to reach the rock, there is a hard soil capable of bearing from 4 to 6 tons per sq. ft., thus doing away with the necessity of any sub-piling.

The method used in building the column piers is to sink a hollow steel caisson, of such length that it will not be overtopped by the water, dredge out the interior to the desired depth, and build the reinforced column in the dry. In some cases the columns rest on solid rock, in others, wooden piles have to be driven inside the cylinders to obtain the necessary bearing support. The size of the columns varies according to conditions. In two docks built in 1910, 140 ft. wide and 780 ft. long, where the mud covering the rock was less than 50 ft., the columns were seated directly on the rock. Where the mud is more than 50 ft. deep the columns rest on five 15-in. wooden piles driven to refusal, the piles being cut off 35 ft. below the water line and encased by the concrete columns to that height. The columns are 6 ft. in diameter to a height of 7 ft., and then 3½ ft. to the top.

In laying out a vast dock improvement proposition at Fort Mason, San Francisco, the government has planned for the immediate construction of three docks of the usual San Francisco type, each to be 500 ft. long, two 81 ft. wide, the third 118 ft. wide. The concrete columns are to be supported by groups of seven wooden piles driven in a circle 6½ ft. in diameter, and 18½ ft. from centre to centre each way. The piers are to be 8 ft. in diameter up to 12 ft. above the dredge line, and are then to be reduced to a diameter of 4 ft. for the remainder of their length. The wooden piles will extend some 11 ft. up into the concrete columns, the bottom of the concrete being well below the mud line. In building the first of these docks, an attempt was made to construct the column forms of 4-in. staves, sufficiently reinforced with bands, and sink them into position by driving. The method did not prove a success, and resort was made to the steel cylinder caisson method, as described previously.

Up to 1911 there were only four modern reinforced concrete column docks under the control of the San Francisco port authorities. Since that time they have added largely to the number by replacing some of the older wooden pile docks with reinforced concrete structures. The first addition was Pier No. 17, 800 ft. long and 126 ft. wide, with suitable railroad track accommodations. It consists of wooden piles protected by concrete shells, the deck-beams being of structural steel encased in concrete, and the stringers and decking are of timber—a sort of semi-concrete pile semi-concrete dock.

The next docks reconstructed were Piers Nos. 26, 28, 30, and 32, all of the same type, having reinforced concrete columns resting on the hard bottom, without any piling, with a complete system of reinforced concrete deck-beams, girders, and slabs. These docks are equipped with up-to-date cargo-handling machinery.

The net addition was Pier No. 39, 150 ft. wide, this being in process of construction at the present time. The concrete columns rest on groups of from 4 to 10 wooden piles, the entire deck system being of reinforced concrete.

In another type of construction at San Francisco the wooden piles are wrapped with wire fabric, or otherwise, and a concrete shell is placed around them after the piles have been driven to place. This method, apparently, has proved successful, though it must be carried on in such a way that the concrete can be poured, set, and hardened in the dry, and not in sea water, if permanent results are to be obtained.

Recently, the City of Oakland, Cal., built a genuine reinforced concrete pile dock, 295 ft. long and 124 ft. wide, standing in 30 ft. of water. The piles are of premoulded concrete, 16 in. in diameter, octagonal, and of a 1 : 1½ : 3 mixture for a distance of 5 ft. from the top, the remainder of the pile being of a 1 : 2 : 4 mixture. The bents and piles are approximately 10 ft. apart. Each row of piles has a concrete cap or girder running athwart the dock, the deck-beams and deck-slab being also of con-

crete. For lateral stiffness, 12-in. concrete curtain-walls were built at three points in the dock, for about one-third of its width, between the piles in three bents.

Portland.—Being 112 miles from the ocean, on a fresh-water river, it is possible to use wooden piling at Portland, in the construction of docks. A massive concrete dock terminal, now being built by the city, consists of four concrete warehouses along the water-front. The dock part of this project as designed consists of a reinforced concrete platform, 1,030 ft. long and 100 ft. wide, 32 ft. above low water, resting on wooden piles driven in groups and cut off at about mean low water. Resting on each group of wooden piles, 20 ft. from centre to centre, are the reinforced columns supporting the upper platform, composed of steel I-beams encased in concrete, and a concrete floor-slab. For a length of 300 ft., a low-level deck, 14 ft. below the main deck, is provided. As the Columbia River is subjected to high- and low-water stages, due to floods, it was necessary to provide this lower platform for use by river steamers during low-water periods. The rise and fall of the Columbia River attains a maximum of about 28 ft., though 18 ft. is about the average, all based on mean low-water level. Thus the lower platform will seldom be under water.

Puget Sound.—Though there are several large shipping ports on Puget Sound, up to the present time, no reinforced concrete dock construction of a commercial nature has been undertaken in these waters. As lumber is so plentiful in that part of the country, it is only natural that such a section should be one of the last shipping centres to take up the building of reinforced concrete docks; but as the destructive teredo is very active there, the engineers of the Northwest are beginning to seek a more stable type of construction than creosoted wooden pile docks, especially the United States and Canadian governments, and some of the railroads, because "in government (and publicly owned) docks, a small saving in first cost is of minor importance, but weakness and frequent need of repairs are well nigh intolerable. On the other hand, in private ownership of docks a saving in first cost is usually of serious importance, while the cost of maintenance, repairs, etc., is met by earnings of the dock and is less felt," unless they become so excessive as to make a concrete proposition more economical in the long run.

At the U.S. Navy Yard in Bremerton, Wash., a reinforced concrete dock, consisting of concrete columns, steel and concrete beams, and a concrete slab, was completed in 1912. It is 402 ft. long and 60 ft. wide. The columns are 3 ft. in diameter, with a flared-out footing to a diameter of 6 ft., 16 ft. from centre to centre, each way, there being four columns to each bent. The caps and girders over the tops of the columns are of I-beams encased in concrete. A concrete beam is run midway longitudinally between each of the four steel beams. The I-beam caps are cantilevered out 6 ft. on each side of the dock. The columns were built as hollow concrete cylinders with a 3-in. shell of 1 : 2 mortar, and filled with a 1 : 2 : 4 concrete after being sunk to place. As hollow cylinders, they avoided any coffer-dam work. The dock has a standard railroad track down each side over the outside columns, also an ordinary wooden fender system.

A still heavier concrete dock is now in course of construction at the same Navy Yard. It is 490 ft. long, 80 ft. wide, and is designed for a load of 600 lb. per sq. ft. The approach of the dock consists of a wooden pile structure, 210 ft. long, of triangular shape. As designed, the structure is supported by sixty-eight concrete columns, 4 ft. in diameter, with an 11-ft. base (of the same type as in the dock just mentioned), 20 ft. from centre to centre athwart the dock, and 30 ft. longitudinally. The columns are capped by extremely heavy reinforced concrete beams which support a series of built-up structural beams, about 36 in. deep, carrying a thick concrete floor-slab. The side of the dock is cantilevered out 8 ft. beyond the columns. A standard railroad track runs over the centre line of the outside rows of columns on each side of the dock. On account of the nature of the soil, some of the piers rest on sub-piling, others, nearer the shore, on hardpan.*

Vancouver.—The Great Northern Railroad has very recently completed an extensive reinforced concrete dock of the quay type, in connection with a new terminal it is building at Vancouver. The total width of the terminal dock is 302 ft., the concrete dock proper being 456 ft. long, and 50 ft. wide on each side of the terminal, the space between being a rock and earth fill, with a proper rip-rapped slope at its faces. Each concrete dock structure consists of nineteen reinforced concrete columns, 4½ ft. in diameter, 25 ft. from centre to centre, parallel to the face of the dock, resting on the rock stratum that underlies the location of the terminal. These columns support a heavy longitudinal concrete girder into which are tied heavy cross-girders, 12½ ft. apart. The cross-girders are cantilevered out beyond the longitudinal girder about 16½ ft., and their inboard ends rest on two driven concrete piles 34 ft. back from the centre of the columns. Four concrete beams of suitable size are run longitudinally with the dock. The entire girder and beam structure supports a concrete slab. The railroad track is over the longitudinal girder running from column to column. The two parts of the dock are tied together by suitable concrete beams running across the interior fill. The terminal is considered to be one of the most substantial and up-to-date structures on the Pacific Coast. The dock is well protected by a wooden fender-pile steel-spring system.

Great Lakes.

Although extensive use of concrete has been made in some of the ports of Lakes Superior, Michigan, Huron, Erie, and Ontario, in the construction of massive ore-docks, it is not proposed to discuss that particular phase of the subject in this paper. These docks are of excellent design, some built on concrete piling, others on wooden piling or cribs. Concrete piles in fresh water are not subject to the same deterioration as those in salt water. On the other hand, they have to withstand extremes of temperature, frost and ice, in addition to severe treatment, due to the heavy traveling machinery above them.

Some of these docks will be discussed, in order to bring out the important features of their special design.

Chicago.—One of the first attempts at using concrete for dock work on the Great Lakes was made at South Chicago, in the winter of 1898-99, in the rebuilding of an old wooden quay dock wall. The concrete structure is 1,680 ft. long, and consists of a heavy mass concrete stepped-back wall, 10½ ft. high, 8 ft. wide on top, and 18 ft. on the bottom, supported by a timber structure consisting of three rows of piling cut off 3½ ft. below mean water level, with longitudinal caps crossed by a heavy wooden grillage. A timber sheet-piling bulkhead under the face of the wall acts as a retainer for the slag fill. On one occasion the wall was rammed by a large steamer, but suffered absolutely no damage. The damage to the steamer, however, was rather extensive. A year or so later, a similar quay dock wall, 2,300 ft. long, was constructed at the same steel plant.

*In the actual construction the built-up structural beams were replaced by reinforced concrete.

Due to the decay of a long wooden water-front bulkhead on the Chicago River, it became necessary to replace it. This was done by constructing a reinforced sheet-pile bulkhead almost ½ mile in length, capped by an I-shaped concrete beam, some 3 ft. wide and 5 ft. high. This beam rests on pre-moulded piles, which are 20 ft. apart and are secured to buttresses, also 20 ft. apart, which run back about 12 ft. from the sheet-piling, the land ends of the buttresses being supported by other piles. The buttresses are also tied back to deadmen some 35 ft. back from the wall. As the bulkhead has about 18 ft. of water along its front, vessels can dock alongside.

Marquette.—The most extensive reinforced concrete ore-loading docks on the Great Lakes are without doubt at Marquette, Mich., and were built in 1912. The substructure consists of a heavy concrete slab and facing-walls, similar to a channel beam placed on its back, 1,500 ft. long and 60 ft. wide, resting on wooden piling. Under the face of the walls there is a wooden sheet-piling bulkhead which retains the sand fill around the piles under the dock structure. The depth of the concrete web is 3 ft., the walls that correspond to the flanges being 9 ft. high. The substructure supports a very massive reinforced concrete superstructure for loading ore into vessels, the whole dock being a very substantial and shock-resisting structure. A steel plate is worked along the face of the two concrete walls from 6 in. below the water level to 3 ft. above it, to prevent disintegration of the concrete due to frost and ice action at the water level.

Two Harbors.—At Two Harbors there is an ore-loading dock consisting of a steel superstructure supported by a mass concrete wall running along each face of the dock, and tied together with concrete beams at regular intervals. The concrete walls rest on wooden piles with a wooden sheet-piling bulkhead to retain the interior fill. The substructure is 1,400 ft. long and 52 ft. wide.

Detroit.—The concrete ore-loading dock at Detroit is 200 ft. long. It consists of three bearing walls of a T-rail shape, 9 ft. deep, running parallel to each other, the two outer walls being 28 ft. apart, the third or back wall being 173 ft. from the middle wall. The three walls rest on a double row of oak piling cut off 3 in. above the water level. Being capped by the concrete walls, no part of the wooden piling is exposed to the air. The outer wall stands in about 10 ft. of water, the middle wall in 3 ft., and the rear wall is far back on the dry land. The two outer walls are tied together by reinforced concrete beams, 5 ft. deep, at intervals of 10 ft., with cantilevered brackets on the water face of the outer wall opposite the tie-beams. The concrete deck-slab on top of the brackets is 12 in. thick, but only 6 in. thick between the two outer walls. The dock has a suitable wooden fender-pile system.

Between the middle and back walls there is a 12-in. reinforced concrete floor-slab, supported on a series of piles, 5 ft. from centre to centre each way, stated to have been designed for a load of 6,800 lb. per sq. ft., or 85 tons per pile. The ore floor is tied into the middle and back bearing walls opposite each cross-beam in the dock proper. The three walls support an ore bridge tower, used for unloading ore from vessels to cars on the track just behind the middle wall, or into the ore bin between the middle and back walls.

Toledo.—At Toledo, Ohio, there is an ore-unloading dock, consisting of a plain concrete wall running along the water-front, resting on wooden piles, and tied back to deadmen some 100 ft. in the rear. The land is reclaimed back to the middle wall, a row of sheet-piling under the river wall retaining the earth in place. Parallel to the river there are three other walls to support the legs of the ore-unloading bridges which run on tracks placed on all four walls, spanning the four car tracks and the ore piles. The distance from the front wall to the inmost land wall is 419 ft.

Cleveland.—There is a full reinforced concrete ore-unloading dock at Cleveland, Ohio, completed in 1912 by the Pennsylvania Railroad. It consists of a reinforced concrete water-front wall, 985 ft. long, supported by a double row of pre-moulded concrete piles. The face wall is tied back by reinforced concrete tie-beams to another reinforced concrete wall supported by three rows of concrete piles about 81½ ft. in the rear. The tie-beams are 30 ft. apart, and rest on concrete piles 6 ft. apart. The space between the two walls, that is, under the concrete tie-beams, is back-filled with rip-rap, the whole mass being pumped full of sand. A concrete sheet-piling bulkhead under the front wall retains the fill in place. The dock has the usual wooden fender-pile protection. The tracks for four 17-ton Hewitt unloading machines run along the inner and outer walls. So far as the writer has been able to discover, this was the first concrete pile dock built on the Great Lakes.

Another ore-unloading dock at Cleveland consists of a reinforced wall of the same type as that at Detroit, the two structures having been designed by the same engineers. The cantilevered face of this wall is supported by brackets at intervals of 15 ft., with rear buttresses opposite them. The buttresses rest on a concrete base slab, the rear edge of which rests on a row of wooden sheet-piling, the base-slab evidently being monolithic with the rest of the wall. The space between the sheet-piling and the wooden piles that support the concrete wall (11 ft.) is filled with slag. In general, the cross-section of the wall is dumb-bell shaped.

General.—In discussing the ore docks of the Great Lakes, it is necessary to consider the special and peculiar conditions under which they are operated, as they are designed to meet these conditions, and not vice versâ. The larger portion of the freight carried on the Great Lakes is of heavy bulk form, viz., ore and grain on the downward trip, coal on the upward trip. Thus ore and coal cargoes form the two heaviest items handled in bulk masses at the terminals. Nowhere in the world is found such massive and modern machinery for the economical and expeditious handling of bulk freight as at the upper and lower ports of the Great Lakes. Consequently, such docks, wooden or otherwise, must not be judged by the type used along the seaboard of the Atlantic, the Gulf, or the Pacific.

It appears that the various types of reinforced concrete docks as worked out by the American engineers are far more numerous than in foreign practice, as is evident from the foregoing descriptions. Although the Atlantic Coast engineers seem to favor pre-moulded concrete piles, the Pacific Coast engineers apparently favor large concrete columns. Perhaps in time a typical American concrete dock will be designed or devised, as in the case of the long-standing type of wooden pile dock structures.

In the foregoing review of American reinforced concrete docks, an effort has been made to include each and every port wherein such types of docks exist, as well as to mention each and every dock already built, so far as the writer has been able to acquire sufficient information concerning them, in order that the exact situation as regards the development of reinforced concrete dock construction in America up to the present time may be known to all.

ROGER'S PASS TUNNEL CONSTRUCTION.

NOTABLE progress has been made by the Canadian Pacific Railway Company on the construction of its double-track tunnel, 26,400 feet in length, through Mt. Macdonald of the Selkirk Range. The following information, together with the illustrations, show that there has been great activity since the establishment of plant and actual commencement of operations.

The elimination of the loops referred to means a reduction of the summit of the line from 4,330 ft. to 3,791 ft., and a reduction of the distance between certain points on the line of from 23 miles to 18 miles. Further, the length of maximum grades upon the present line is 22.15 miles, whereas the length of maximum grade on the proposed line will be only 6.61 miles.

The preliminary work included a large amount of excavation and fill in order to obtain grade for entering the

Enormity of Roger's Pass Tunnel Scheme as Viewed from One of the Portals.

Readers of *The Canadian Engineer* are referred to our issue of April 23, 1914, for a general description of the undertaking and also for a detailed outline of the plan adopted by the contractors for its successful carrying out. The tunnel, it will be remembered, is to enable the Canadian Pacific Railway to dispense with its "loops," together with many miles of snow sheds, to reduce the distance from valley to valley, to effect an enormous grade reduction, to obviate the use of "pusher" engines over the long section of main line, and, in short, to eliminate the use of one of the most costly sections, from a railway operating point of view, to be found on the continent.

tunnel at the western portal. At the present time this work, with the exception of a small portion, has been completed. Another preliminary undertaking, and one that had some very novel features connected with it, was the deviation of the Illecillewait River so as to utilize its old bed for an approach. A trench nearly a mile in length was excavated and the river now takes a new course in front of the spot chosen for the entrance of the tunnel, while lower down the valley a culvert was constructed to return it to its original course. A similar task was necessary in the Beaver Valley on the eastern slope.

As stated in the article previously referred to, the method of tunneling includes the driving of a "pioneer" shaft. This is a heading 7 x 9 ft. in cross-section, which is being driven 45 ft. from the centre line of the main tunnel, but with 10 ft. greater elevation. The main line of the tunnel will then be worked from cross-cuts. This is a new method of tunnel projection which is being tried out by the contractors to expedite operations. The pioneer bore, when completed, will be an entirely separate tunnel paralleling the course of the main passage through the mountains. The activities of drillers can thereby be concentrated at many different points simultaneously.

handfuls between the stoping and its use has been pronounced exceedingly satisfactory. The excavation is being effected by steam shovel, which will be used until rock has been encountered. The 600 men at present at work on the tunnel are accommodated in two camps, one at each portal.

The work commenced in June and is to be completed by December, 1916. It is under the direction of Mr. J. G. Sullivan, Chief Engineer for Western Canada of the Canadian Pacific Railway. The contractors are Messrs. Foley, Welch and Stewart, of Seattle, Wash. The estimated cost of the scheme, with related improvements in

Roger's Pass Tunnel, Selkirk Mountains, B.C., Present Terminal Stations and Constructional Views.

The course of the pioneer bore on the west side of Mt. Macdonald is in a downward direction, beginning several hundred feet above the cutting. It descends on a 50% grade for the first 300 ft., after which it proceeds horizontally. Since last April, when it was stated in these columns that over 1,100 ft. of the pioneer tunnel had been driven from the eastern portal, over 2,000 ft. more has been projected, while practically 1,000 ft. of the main tunnel has also been driven from the eastern portal. On the west side the bores for the main tunnel are not advanced to such a stage, but are well under way, and three cross-cuts have been driven.

An interesting feature of the boring operations in the soft material at the western entrance of the main tunnel is the use of hay to arrest the flow of loose earth and water as the excavation proceeds. The hay is placed in the way of electrification of the tunnel portion of it and double tracking, exceeds $10,000,000.

At the Foundry and Machine Exhibit held in Chicago, September 5 to 11, the Wernicke Hatcher Pump Co., Grand Rapids, Mich., displayed in operation a new compact type of air compressor. It has a balanced rotary movement giving positive displacement, and works up to 100 lbs. or more in a single stage. This is obtained with unusually efficient cooling and low-power consumption; while the rotary principle means a steady flow of air uniform running and low-starting torque. It also permits direct connection to a high-speed electric motor, with ready control at all speeds up to maximum. The machine is portable and requires neither a heavy foundation nor piping.

HARRISBURG FILTER CASE.

In *The Canadian Engineer* for September 18, 1913, a review was given of a decision handed down by the United States Circuit Court of the Middle District of Pennsylvania in connection with the "negative-head" patent case between the New York Continental Jewell Filtration Company and the City of Harrisburg, Pa.

The case, which has been on trial since 1908, has just been the recipient of another decision, this one from the United States Circuit Court of Appeals of the Third Circuit. It was handed down on September 15th, 1914, and reverses the decision of the Lower Court.

In view of the attention which the long trial has occasioned, the following notes respecting the new decision may be of further interest.

The opinion starts with a brief statement of the claims of the patents in suit and follows with a general discussion of the principles of filtration and the state of the art. A very extended review of the language of the various patents referred to in the suit is then given, followed by a discussion of the principles of suction as applied to this case.

The court points out various patents which were cited by the city as anticipations of the patents in suit and reviews in this connection several instances of prior use claimed by the city, and proceeds then to a discussion of the scientific principles involved in the patents in suit and the theories of the patents as disclosed by the evidence. The judge writing the opinion gives the impression that the plaintiff company has not proved its case in this regard, and cites the testimony of several witnesses on both sides which apparently created in the court's mind a doubt about the matter, but the judge expressly refrains from making any decision on these matters. This is clearly indicated in the summing up of all this discussion in the following words:

"However, it is probably enough to say that (at the best) the evidence in behalf of the company leaves us in much uncertainty whether the theories of the patents are sound. We do not feel bound to go the length of declaring the patents invalid—the re-issue patent, indeed, has already expired, leaving the patentee only a claim for royalties—but we are prepared to say that while the subject is so surrounded by uncertainty the company cannot reasonably object to the application of a test that tries the Harrisburg filters by the theories of the patents."

The court specifically declines to state that the patents in suit are not valid, or that the scientific principles and theories upon which the plaintiff company based its claims are incorrect.

But in reviewing the testimony of what actually happened at Harrisburg, the court decides that that was not sufficient to create an infringement, concluding with the following words:

"In our opinion, therefore, the case may safely be decided by finding upon the evidence that the city has not infringed either patent."

In brief, it appears that this decision, while reversing the decision of the Lower Court as to Harrisburg, does not decide that the theories of the court below were wrong with respect to the basic principles upon which that court decided the case, and leaves open the entire question as to validity of the patents.

It is reported that probably one of the largest contracts ever secured by Chilean manufacturers was recorded on July 6, when the Government placed a home order for railway equipment to the value of $8,240,000.

SOME TUNNELING COSTS.

(Continued from last week's issue.)

Marshall-Russell Tunnel.

Location: Empire, Colo.

Purpose: Mine drainage, development and transportation.

Cross-section: Rectangular.

Size: 8 feet wide by 9 feet high.

Length: 11,000 feet projected; 6,700 feet driven January 1, 1913.

Character of rock penetrated: Granite and gneiss.

Type of power: Purchased electric current; also a small auxiliary hydraulic plant.

Ventilator: Fan.

Size of ventilating pipe: 12 and 13 inches.

Drills: 2, pneumatic hammer.

Mounting of drills: Vertical columns.

Number of holes per round: 18 to 20.

Average depth of round: 9 to 10 feet.

Number of drillers and helpers per shift: 2 drillers and 2 helpers.

Number of drill shifts per day: 1.

Explosive: 40 per cent. gelatine dynamite; with some, 80 per cent.

Number of muckers per shift: 4.

Number of mucking shifts per day: 1.

Type of haulage: Horses.

Wages: Drillers $4, helpers $3, blacksmiths $4, helpers $3, muckers $3.25, trammers $3.75, dumpmen $3.25, power engineer $3.50, shooters $3.25.

Maximum progress for any calendar month: 187 feet, June, 1909.

Average monthly progress: 125.

Cost of Driving Tunnel 6,700 Feet.

	Cost per foot of tunnel.
Labor	$ 9.37
Powder, fuse, caps and blacksmith coal	3.35
Drills, steel and repairs (less 30 per cent. salvage)	1.34
Power	1.41
Permanent equipment and general expense (less 30 per cent. salvage on permanent equipment)	3.41
	$18.88

Mission Tunnel.

Location: Santa Barbara, Cal.

Purpose: Water supply.

Cross-section: Trapezoid.

Size: 6 feet wide at the base, 4½ feet wide at the top, 7 feet high.

Length: 19,560 feet.

Character of rock penetrated: Shale, slate and hard sandstone.

Ventilator: Pressure blower.

Size of ventilating pipe: 10 inches.

Drills: 1 pneumatic hammer.

Mounting of drills: Horizontal bar.

Number of holes per round: 12 to 14.

Average depth of round: 7 to 8 feet.

Number of drillers and helpers per shift: 1.

Number of drilling shifts per day: 3.

Explosive: 40 per cent. and 60 per cent. gelatine dynamite.

Number of muckers per shift: 4.

Number of mucking shifts per day: 3.

Type of haulage: Electric.

Wages: Drillers $3.50, helpers $3, muckers $2.75, blacksmiths $4, helper $3, motormen $2.75, dumpmen $2.50, power engineers $2.75.

Maximum progress in any calendar month: 414 feet, February, 1911.

Average monthly progress: 210 feet.

Cost of Driving the South Portal, Mission Tunnel, 5,515 Feet.

	Cost per foot of tunnel.
Administration	$ 1.14
Labor	9.20
Power	2.12
Explosives	1.97
Timbering (563 feet)	.30
Track and pipe	1.22
Miscellaneous supplies	2.46
Drill parts (including steel)	1.02
Bonus	.48
	$19.91

"Administration" includes superintendence, office supplies and general charges. "Miscellaneous supplies" includes candles, light globes, shovels, picks, blacksmiths' supplies and fuel and machinists' supplies.

NEWHOUSE TUNNEL.

Location: Idaho Springs, Colo.

Purpose: Drainage and transportation.

Location: Idaho Springs, Colo.

Purpose: Drainage and transportation.

Cross-section: Square.

Size: 8 by 8 feet.

Length: 22,000 feet.

Character of rock penetrated: Idaho Springs gneiss.

Type of power: Purchased electric current.

Ventilator: Pressure blower.

Size of ventilating pipe: 18 inches.

Drills: Pneumatic hammer.

Mounting of drills: Vertical column.

Number of holes per round: 14 to 22.

Number of drill shifts per day: 1 and 2.

Explosive: 40 per cent. gelatine dynamite, with some 100 per cent. in the cut holes.

Number of muckers per shift: 3.

Number of mucking shifts per day: 1 to 2.

Type of haulage: Electric.

Wages: Drillers $4 to $4.50, helpers $3.25 to $4, muckers $3.50, motormen $3.50, dumpmen $3, blacksmiths $3.50 to $4.50, helpers $3.

Cost of Driving the Newhouse Tunnel.

	Jan. to Aug. 1909, 2,233 feet.	Sept. to Dec. 1909, 1,098 feet.	April to Aug. 1910, 693 feet.
Labor	$ 6.72	$ 6.98	$11.73
Explosives	4.15	3.52	4.57
Fuse and caps	.39	.36	.44
Transport'n of materials broken	1.49	1.47	2.22
Power	1.99	2.16	2.82
Blacksmithing	1.57	2.61	2.00
Use of drills, repairs and steel..	1.50	2.74	2.86
Equipment, ties, rails, pipe, etc.	1.74	1.78	2.19
Sundries	.79	.80	1.85
	$20.34	$22.42	$30.68

RAWLEY TUNNEL.

Location: Bonanza, Colo.

Purpose: Mine drainage and development.

Cross-section: Trapezoidal.

Size: 8 feet wide at the base, 7 feet wide at the top, 7 feet high.

Length: 6,235 feet.

Character of rock penetrated: Tough, hard andesite.

Type of power: Steam with wood for fuel.

Ventilator: Pressure blower.

Size of ventilating pipe: 12 and 13 inches.

Drills: 2 pneumatic hammer.

Mounting of drills: Horizontal bar.

Number of holes per round: 23 to 25.

Average depth of round: 8 to 9 feet at first, 5 to 6 feet later.

Number of drillers and helpers per shift: 2 drillers and 2 helpers.

Number of drill shifts per day: 2 at first, 3 later.

Explosive: 40 per cent. and 60 per cent. gelatine dynamite (in the proportion of about 2 to 1).

Number of muckers per shift: 4.

Number of mucking shifts per day: 2 and 3.

Type of haulage: Horses and mules.

Wages: Drillers $4.50, helpers $3.75, muckers $3.50, blacksmiths $4.50, drivers $3.50, power engineers $4.

Maximum progress in any calendar month: 585 feet, July, 1912.

Average monthly progress: Approximately 350 feet.

Cost of Driving the Tunnel 6,235 Feet.

	Cost per foot of tunnel.
Drilling and firing	$ 5.25
Mucking	2.16
Tramming	1.13
Track and pipe	.44
Miscellaneous underground expenses	1.44
Power plant	2.50
Blacksmithing	.73
Miscellaneous surface work	.83
General expenses	1.98
Permanent plant	3.24
Timbering (1,618 feet)	1.18
Boarding house, debit balance	.04
	$20.98
Credit by salvage on permanent plant	1.11
	$19.87

ROOSEVELT TUNNEL.

Location: Cripple Creek, Colo.

Purpose: Mine drainage.

Cross-section: Rectangular, with large ditch at the side.

Size: 10 feet wide by 6 feet high.

Length: 15,700 feet.

Character of rock penetrated: Pikes Peak granite, chiefly.

Type of power: Purchased electric current.

Ventilator: Pressure blower.

Size of ventilating pipe: 16 and 17 inches.

Drills: 3 pneumatic hammer.

Mounting of drills: Horizontal bar.

Number of holes per round: 24, usually.

Average depth of round: 6 to 7 feet.

Number of drillers and helpers per shift: 3 drillers, 2 helpers.

Number of drill shifts per day: 3.

Explosive: 40 per cent., 60 per cent., and some 100 per cent. gelatine dynamite.

Number of muckers per shift: 4, usually.

Number of mucking shifts per day: 3.

Type of haulage: Horses and mules.

Wages: Drillers $5, helpers $4, muckers $3.50, power engineer $4, blacksmith $5, helper $3.50, dumpman $3.50, drivers, inside, $5, outside, $4.

Maximum progress in any calendar month: 435 feet, portal heading, January, 1909.

Average monthly progress: Portal heading, 300 feet; shaft headings, 270 feet; all headings, 285 feet.

Cost of Driving Tunnel.

Total cost of portal work	$111,980.06
Contractor's percentage	11,404.88
Cost of shaft headings	262,126.55
Total cost of tunnel	$386,421.49
Number of feet driven	14,167
Average cost per foot	$27.27

Cost of Driving the Portal Heading.

	Feet.	Cost per foot.
1908—February and March	514	$22.690
April	262	30.970
May	268	26.760
June	187	35.010
July	203	29.600
August	300	21.760
September	351	19.600
October	287	23.000
November	360	21.120
December	334	18.350
1909—January	435	16.410
February	290	22.206
March	340	21.745
April	316	21.266
May	402	18.762
June (8 days)	62	40.600

Cost of Driving Shaft Headings.

	Feet.	Cost per foot.
1908—October (2 headings)	49	$105.52
November (2 headings)	141	44.38
December (2 headings)	177	40.11
1909—January (2 headings)	261	24.06
February (2 headings)	601	23.70
March (2 headings)	639	26.256
April (2 headings)	670	25.02
May (2 headings)	552	28.34
June (2 headings)	498	27.375
July (1 heading)	319	32.871
August (1 heading)	410	27.747
September (1 heading)	355	32.40
October (1 heading)	380	28.178
November (1 heading)	298	34.20
December (1 heading)	251	35.153
1910—January (1 heading)	282	28.82
February (1 heading)	259	30.636
March (1 heading)	344	27.62
April (1 heading)	376	25.313
May (1 heading)	393	24.856
June (1 heading)	373	26.616
July (1 heading)	350	25.247
August (1 heading)	372	25.029
September (1 heading)	342	28.45
October (1 heading)	372	27.361
November (1 heading)	192	27.786

Typical Distribution of Expenses, Portal Heading, July, 1908, 203 Feet.

	Cost per foot of tunnel.
Machinery and repairs	$ 0.61
Air drills and parts	.99
Picks, shovels and steel	1.90
Ditch men	1.09
Explosives	6.90
Candles	.36
Oil and waste	.09
Electric power	2.06
Blacksmith supplies	.09
General expense	.16
Liability insurance	.17
Lumber, ties and wedges	.01
Horses and feed	.01
Compressor men	1.79
Drillers and helpers	4.21
Blacksmiths and helpers	3.43
Muckers and drivers	4.11
Foremen	1.50
Bookkeeper	.12
	$29.60

Typical Distribution of Expenses, Shaft Heading, February, 1910, 259 Feet.

	Cost per foot of tunnel.
Maintenance of buildings, tents, etc.	$ 0.096
Machinery and repairs	1.158
Air drills and parts	1.930
Shovels, picks and steel	1.930
Pipe and fittings	.193
Ditch men	1.480
Explosives	5.032
Lamps and candles	.217
Oil and waste	.252
Electric power	2.440
Blacksmith supplies	.150
Liability insurance	.213
General expense	.342
Lumber, ties and wedges	.119
Horses and feed	.324
Machine men and helpers	4.050
Muckers	3.065
Blacksmiths and helpers	1.362
Engineers	1.300
Pipe and track men	.675
Drivers and dumpmen	2.355
Foremen	1.753
Mine telephone	.008
Bookkeeper	.193
	$30.636

(To be continued.)

Preparations have been completed by the Quebec Government to open new districts to the lumber and pulp industries. During August and September, limits in the Abitibi and Lake St. John districts were auctioned off. In the Lake St. John region, the territory to be opened is north of the lake and in the basin of the Mistassini and Rat Rivers. In the Abitibi district, it is situated south of the Transcontinental, but on the north slope in the basin which empties into James' Bay. This tract is traversed by the Poisson Blanc, Harricana and Bella Rivers. Both limits have been carefully surveyed by the forestry service.

Editorial

AVOIDING THE MUNICIPAL BREAD-LINE.

Directly in line with what we have been endeavoring to impress upon public bodies throughout the Dominion in the matter of undertaking works such that will provide employment to those whose need of it is to be anticipated, it is worthy of note that the Toronto Hydro-Electric Commission has sought special permission to borrow $2,000,000 for extension work to be carried out this fall and winter. It is reported also that the town of Orillia has made arrangements with the Ontario Government for the clearing of a large tract of bush land during the winter by the unemployed, it being anticipated that the work will be sufficient to provide all the employment required in that town. It is also notable that the Toronto City Council has agreed to the Hamilton-Toronto highway proposal, commented upon in our issue of September 24th, thereby authorizing the expenditure of Toronto's share, $150,000, toward the enterprise.

Such undertakings as these are admirable at this period when so much depends upon the projection of work that will reduce as low as possible the numbers of unemployed that will accumulate in our towns and cities as winter sets in. The Lord Mayor of London recently expressed a feeling that is prevalent at this time not only in England but throughout the Empire's Dominions: "If we can go forward as far as possible," he said, "with our building, manufacturing and other enterprises, limiting unemployment and preserving wages, we shall be doing a very patriotic work." Even in England, whose connection with the European combat is incomparably closer than our own, the enlargement of enterprises of local authorities and other public bodies is going on apace. On the suggestion of the Local Government Board of England, most of the corporations and district councils in the country have already begun to prepare and carry out important schemes of engineering in order that during the coming winter full employment may be found for every workman, and any men thrown out of work from other industries may be kept fully employed. Special facilities for the immediate execution of such schemes are being afforded by loans and by grants from the Local Government and Road boards. Manufacturers of plant and materials for municipalities are acting upon the wise counsel to prepare well in advance for the demands which the above activities will make upon them. It is also to be remembered that the British Parliament has passed the Housing Act providing £4,000,000 for the erection of laborers' cottages. Moreover, H.M. Office of Works has decided to proceed with all services in its charge, to employ as many men as possible in the carrying out of such services, and to develop and expedite its building program in every practicable way. Optimism prevails throughout Great Britain that private individuals, companies, firms and contractors will spare no effort to follow the policy of the government in this matter.

The provision of employment is a subject which should be more seriously considered by our municipal councils. Every town or city has works of some light and unimportant nature that have been persistently overlooked and sidetracked for the sake of more important undertakings. There may be small matters of grading or diversion within the corporation, cleaning of water mains and sewerage systems, or any one of a number of odd jobs which have long awaited attention and which may well be taken up at this time. There is, for instance, always a greater or less need for more activity in the matter of street and property cleaning. Clean-up weeks have produced very beneficial results in a few cities at home and many abroad. A widespread activity throughout the Dominion would mean much toward the health and picturesqueness of communities. Besides, the cleaning up of our streets and alleys and the straightening up of our parks and playgrounds, if completed this fall, will have a decided effect upon the health and appearance of our cities when the snow takes its departure in the spring. There is always the possibility of work going ahead with such a rush at the opening of the season as to necessitate the shelving, once again, of such jobs as these, with undesirable result. Every small amount of work of this nature afforded by our municipalities is going to make better citizens, prevent long bread-lines, and display a true spirit of patriotism.

LIEUT.-COL. HON. JOHN STRATHEARN HENDRIE.

The appointment of Lieut.-Col. Hon. J. S. Hendrie, M.P.P., C.V.O., to succeed Sir John Gibson as Lieutenant-Governor of Ontario, is one that has come to pass during the past few days. Those who are familiar with Col. Hendrie's devoted service as a member of the Hydro-Electric Power Commission of Ontario, and with his connection with the Hamilton Bridge Works Company, now as president, and for many years as general manager, know him to be an engineer with high technical attainments and business qualifications. It is conceded that it will be difficult to fill his place so adequately upon the Commission, but undoubtedly the service which he will render to the province in his new office will be most creditable, both to himself and to the choice of man for the high position he has undertaken to fill.

RUBBER-PAVED ROADS.

It is not yet practicable to construct roads with surfaces of rubber except at a cost of $25 per super yard. But there is little doubt that they will ultimately be adopted. At the International Rubber Exhibition held in London last July, rubber paving was shown both for use on footways and on carriageways which attracted a considerable amount of attention. In each case the rubber constituted a surface cushion on blocks of jarrah wood, the material being held tightly in position by dovetailing, while a special joint locked the paving, preventing, when laid, the access of water to the concrete foundations. It is contended that thinner foundations are necessary owing to the reduced amount of vibration which occurs by heavy and fast-moving traffic, and further, that it never becomes slippery and that motor vehicles do not "skid" upon it under unfavorable conditions of weather. A section of rubber paving has been laid in the Old Kent Road, Lon-

don, for nearly 12 months where the traffic is heavy, amounting to 90 tons per square foot per hour for 24 hours, and is not perceptibly worn.

Another section of road is about to be laid in Cannon Street in the heart of the City of London, the corporation having granted the necessary permission to the acting agent of the Federated Malay States Government in order that its advantages can be better observed by all interested in the new development.

ROAD OIL SPECIFICATIONS AND TESTS.

IN the California Highway Bulletin for July, 1914, Mr. Clarence B. Osborne, Geologist to the California Highway Commission, presents the following specifications for and results of tests of asphaltic oil for road building. He states that in the preparation of such specifications the engineer has three problems presented: (1) He must have requirements controlling the chemical purity of the oil, i.e., he desires an oil that is free from foreign material and products of decomposition produced during refining. (2) He must control the chemical composition of the oil. (3) He must control the physical properties of an oil so that it will actually perform its proper function in the road construction.

Specifications for chemical purity of road oil are as follows:

(1) It shall not contain more than one-half of one per cent. of sediment by volume.

The presence of even ten times this amount of sediment is not detrimental, as the oil in use on the road eventually carries as high as 90% of mineral aggregate. This specification is used to prevent the buying of sediment at the price of road oil.

(2) It shall not contain more than one per cent. of water by volume.

The presence of water in a road oil makes the oil difficult to handle when heated above 212° F., because the steam formed makes the oil boil or froth. Also, as in the case of sediment, unless the proper deduction is made water will be paid for at the price of road oil.

(3) It must, when freed from water, be soluble to at least ninety-nine and five-tenths per cent. (99.5%) in pure carbon disulphide.

This will give the per cent. of bitumen in the road oil.

(4) The bitumen soluble in carbon disulphide must be soluble in carbon tetrachloride to the extent of at least ninety-nine per cent. (99.0%).

The failure to pass this specification is supposed to be an indication of an overheated or "cracked" oil. Carbon tetrachloride is not a stable solvent in bright light and the solubility test is influenced if the test is performed in bright light.

Another specification sometimes used to determine a "cracked" oil is as follows:

(5) In CS_2 bromide solution. The bitumen soluble in carbon disulphide must be soluble to the extent of at least ninety-nine and eighty-five one hundredths per cent. (99.85%) in a solution of one hundred and thirty-five (135.0) milligrams of bromine to one hundred (100.0) cubic centimeters of the carbon disulphide, when twenty-five (25.0) cubic centimeters of the solution are poured on two (2.0) grams of the oil in an Erlenmeyer flask, which is then shaken in the dark for three (3.0) minutes, the solution being immediately filtered through a Gooch crucible using a suction equal to a column of mercury more than eight (8.0) inches high.

When the solution has all passed through the crucible, the crucible is washed with pure carbon disulphide, dried at from two hundred and twelve (212.0) to two hundred and twenty degrees Fahrenheit and weighed.

This test had its origin in the examination of vegetable and animal fats. The unsaturated fatty acids form insoluble bromides. This bromide carbon disulphide solvent is not stable, however. An oil having an excess of 0.15% of insoluble material would fail to pass this specification, and yet this failure might be due entirely to the unstable solvent.

The specifications to govern the different constituents that make up the bitumen of the road oil are partly included in the specifications numbered (3), (4) and (5).

The road oils are generally classified as to their asphalt content. This asphalt is not a definite chemical compound determined by chemical analysis. To determine the asphaltic content, the road oil is hardened by heating it in an asphalt oven at a high temperature. Part of the light or volatile oils, is driven off in this heating and the residue is hardened. The degree of hardness is measured by the depth of penetration of a No. 2 needle when acting under a load of 100 grams for five seconds, the residue being maintained at 77° F. If the needle penetrates 8 mm. in this test the residue, called asphalt, is said to be asphalt of 80 penetration. As can readily be seen, this residue may contain many different bitumens. The test is not a measure of a definite chemical compound.

If the assayer for copper should call all the metal extracted "copper" when the metal was of a certain hardness, then it can readily be seen that any alloy of soft and hard metals that made this certain hardness would be classified as copper. This is the practical result of the specification for a road oil when it is required to contain a certain percentage of asphaltum.

The early oil-bound macadam roads built with asphaltic oils usually required an oil containing 70 to 75% of asphalt of 80 penetration. This oil was not heavy, that is, it lacked body (*i.e.*, low viscosity), and it was a weak binder but it was easily applied to the road surface.

The use of pressure tank wagons with sprayers for applying heated road oil has made it possible to use an oil of much higher asphalt content and of higher viscosity. The road oil that is now commonly demanded for oil-bound macadam, or for bituminous-covered concrete highways, is one that contains 90% of 80 penetration asphalt. The following specifications are suggested for such an oil:

(6) It shall contain 90 per cent. of 80 penetration asphalt.

This per cent. of asphalt is determined by heating 20 grams of the road oil in a 2-oz. salve tin in a standard asphalt oven, the temperature of the oven being maintained at 400° F. When the asphaltic residue has a penetration of 80, the oil shall not have lost in excess of 10% by weight.

The asphaltic content is the classification of the oil refineries of their different grades of road oil. The specification is of value more on this account than for any information of practical value furnished to the road builder.

(7) It shall show an open flash point not less than 350 degrees Fahrenheit.

This requirement prevents the use of an oil carrying very volatile constituents that would readily evaporate and might also be dangerously combustible at the time

the oil was being sprayed on the road at the high temperature necessary for spraying.

The physical properties of a road oil are of the greatest importance to the road builder. The following specifications deal directly with the measurement of the important physical properties:

(8) It shall show a float test of not over 1,000 seconds when tested at 90 degrees Fahrenheit. This test is described in Bulletin No. 38 issued by the Office of Public Roads, United States Department of Agriculture.

This float test is the measurement of the viscosity of a road oil. The requirement will prevent the use of excessively viscous road oil, one that is difficult to apply and is slow to absorb the mineral aggregate necessary to the building up of the proper wearing surface.

(9) The oil shall show a specific viscosity of not more than one hundred (100) when tested with the Engler viscosimeter at a temperature of two hundred and twelve (212) degrees Fahrenheit.

This test will prevent the use of an oil that is too viscous to be readily applied to the road surface from the oil-spraying wagon.

(10) It shall show an adhesive test of not less than 300 seconds for three revolutions with the Osborne adhesive machines, when the oil is tested at a temperature of 77 degrees Fahrenheit, the load being 3 kilograms.

This test is the measure of the oil's power to prevent relative motion of two concentric cylinders which the oil acts as a binder between the surfaces of the two cylinders. The inner cylinder is 1.995 in. in diameter, the outer cylinder is 2 in. in diameter, the outer cylinder being in the form of a loose collar 2 in. wide. Its inner surface is coated with the oil to be tested. The outer surface of the inner cylinder is coated with oil and the collar then forced on the inner cylinder, which is maintained in a stationary position.

The outer collar is wound with cord to which a three-kilogram weight is attached; the pull of this weight causes the collar to revolve; the thin film of road oil between the two cylinder surfaces offers a resistance to this turning. The temperature of the oil being tested is maintained at 77° F. by means of water circulating in the inner cylinder. The measurement of the adhesive value of the oil is the length of time required for three complete revolutions of the collar.

Oils containing the same percentage of asphaltum will often show the greatest difference in their binding properties. Oils possessing the same viscosity will likewise often show a wide difference in adhesiveness.

As an example, one oil may be largely made up of heavy lubricating grease, another may be very free from lubricating material but they may both flow through a given-sized orifice at the same rate, when heated to the same temperature, that is, they have the same viscosity. The lubricating oil would lack binding power and be unsatisfactory for road construction; the other would be desirable. The adhesive specification would prevent the use of the unsatisfactory lubricating oil.

The asphalt contained in a road oil is required by some road builders to possess a certain ductility.

(11) The ductility of the asphalt which has been reduced to a penetration between 75 and 85 shall not be less than 110 centimeters.

This test is made with asphalt maintained at 77° F. and the pulling shall be at the rate of 5 cm. per minute, using the Dow ductility machine.

There is a woeful lack of uniform specifications for road oil and uniform methods of performing the tests. In the determination of the asphaltic content of an oil, the temperature for the asphalt oven is specified sometimes at 325° F., and from that to as high as 500° F.

The dish containing the road oil during the reduction is in some laboratories as small as a thimble, and in others, large enough to hold 500 grams; sometimes cylindrical, and others times semispherical in shape. Some tests require the use of an oven, others require heating in the open air. As has been shown, the "asphaltic content of an oil" is, at best, a rather indefinite term, and when we have added to this the different methods used and the wide range of equipment used, the "asphaltic content" becomes even more of a vague description.

The asphaltic road oils are, for the most part, a by-product of the oil refineries. They are a relatively cheap material. This cheapness saves the road oils from being adulterated with other material. It is expensive to add anything to the oil. The natural oil itself rarely carries undesirable material. The tests for water and sediment will take care of foreign materials brought in by the crude oil.

Some road engineers have regarded oil containing sulphur as dangerous to use because the sulphur is supposed to make the product unstable. Many oils and asphalts carrying sulphur have given good service for long periods of time and if sulphur does tend to make the oil unstable, this action is too slow to be of importance in the life of the oil used in the road construction.

MANY EUROPEAN NATIONS TO BE REPRESENTED AT PANAMA EXPOSITION.

In answer to numerous inquiries, President Charles C. Moore of the Panama-Pacific International Exposition, to open in San Francisco on February 20, 1915, has issued the following statement:

"One month ago, the decision of the Panama-Pacific International Exposition management not to postpone was first published. At the time the decision was made no word had been received from any foreign nation as to the effect on its plans caused by the European war, but it was hoped that at least those nations not fighting would go on with their plans. Later developments have proven that hope well founded; in addition, we have definite assurances from France, from Italy, from Turkey and from Japan that their intentions are unchanged. Holland has added $300,000 to her original appropriation. Italy has ordered work on her building and exhibits rushed. Japan has asked for and received an increase of space. The Argentine Republic has increased its appropriation from $1,250,000 to $1,750,000.

"We shall undoubtedly lose some of the promised exhibits from Europe, but not by any means all of them and not by any means the most important of them. Both Germany and Great Britain will be represented by individual exhibitors or by associations thereof.

Another evidence of the growing demand for American steel for South America was shown when orders were received at Pittsburg, Pa., for 100 miles of 80-pound steel rails. The order is the largest that has reached Pittsburg rail mills since the trend of the business to this country from South America began. The contract was placed with the United States Steel Products Company, the export department of the United States Steel Corporation.

Coast to Coast

Edmonton, Alta.—The 3-story structure being erected by the Bank of British North America has been completed at a cost in all of approximately $160,000.

Collingwood, Ont.—The corner-stone of the new Federal building, which is being erected at Collingwood by the Dominion Department of Public Works, was laid on September 10th.

Hamilton, Ont.—Much satisfaction is being expressed by citizens of Hamilton with the work being done on new civic roadways this year under the supervision of Mr. Eugene Whitley, assistant city engineer.

Regina, Sask.—The operation returns of the Regina Street Railway Department for the week ending September 5th showed a revenue of $3,322.60; while for the week ending August 29th, the revenue shown was $3,378.05.

Oakville, Ont.—Repairs to the piers at Oakville harbor are in progress. The wall has been raised at the east side, the floor has been levelled, and new sleepers have been installed. When the east pier has been fully repaired, the west pier will also receive attention.

Saskatoon, Sask.—The Dominion Interior Elevator at Saskatoon was to be ready for operations about 15th September. The structure is considered to be one of the finest pieces of construction of the kind on the American continent. The capacity of the present initial unit is 5,000,000 bushels, and its cost is about two million dollars.

Windsor, Ont.—On September 12th, Sir Adam Beck, chairman of the Ontario Hydro-Electric Commission, performed the inauguratory function of releasing to public service in the entire business section and many of the principal residential districts of Windsor electric light and power generated at Niagara Falls, 250 miles from the former city.

Winnipeg, Man.—During August the steam and electric pumps at Winnipeg handled 328,697,210 gallons of water as compared with 342,426,000 gallons in the corresponding month of 1913, a decrease of 13,545,390 gallons. The rate per 24 hours for August this year was 10,603,135 gallons, as compared with 11,040,083 gallons in 1913, a daily decrease for August this year of 436,948 gallons.

Fort William, Ont.—The financial report of the utilities of Fort William for the first six months of 1914 shows a total profit on the operation of all utilities of $20,954.34. Water shows a surplus of $5,463.97 above maintenance and fixed charges, the revenue being $47,653.44; light, a surplus of $14,245.55, and revenue of $59,912.80; and telephone, surplus, $1,244.82, revenue $31,565.16.

Regina, Sask.—A recent report made by the superintendent of the Regina street railway department to the utilities committee of the city council showed that expenses on that department are being steadily curtailed. Receipts for this year compared favorably with corresponding periods of 1913; and the operating expenses showed a decrease over last year, current figures being 92.9 per cent. as against 115.7 per cent. in 1913.

Regina, Sask.—A report upon the work being done by the provincial public works department on a large reinforced concrete culvert near Clark's Crossing, announces that this work is well under way and will be completed within a few days. Announcement is also made that the concrete bridge and dam being undertaken by the department near McTaggart E. 3-10-15 w. 2 are now under way and will be carried to completion.

Peterborough, Ont.—Work to proceed and be completed at Peterborough this autumn includes street paving and sewer construction, and the reconstruction by the G.T.R. of 50 miles of roadbed between Lindsay and Hastings. Moreover, it is understood that the Utilities Commission has under contemplation the extension of its mains, and that the Peterborough Radial Railway Company is prepared to rebuild immediately a portion of its Charlotte street line if the city will decide to pave the same section at the same time.

Fort William, Ont.—The depression caused by the outbreak of the war at Fort William was of short duration. About two weeks ago work was recommenced with a rush by the three transcontinental roads which make that city their lake terminus. The C.P.R., C.N.R., and G.T.P. doubled their rolling stock and equipment to provide for the shipping of grain into the city; and it is expected that this state of affairs will last well on into the winter, since rail shipments to west St. John this year will doubtless be the heaviest in history.

Victoria, B.C.—The tunnel at Macaulay point for the Northwest sewer at Victoria has been pierced after over 5 months' work, and is the first of 4 to be completed on this project. A second, that at Gore street, will be finished in about six or seven weeks, as there is only another 180 feet to complete. The other tunnels will not be finished this year. About 450 feet of the 1,800 feet in the Sunnyside tunnel has been pierced; while the other long tunnel of 2,700 feet will not be finished till the new year. The tunnel between Thomas and Robert streets, which is now opened, will be cleaned up and finished shortly, and the sewer pipe will be laid.

Regina, Sask.—Considerable work has been undertaken by the board of highway commissioners in Saskatchewan, arrangements having been made for an expenditure of $500,000 in road and bridge work. At the beginning of the current month, 150 road gangs, with crews of from 15 to 20 men each, and using 10 to 12 teams, commenced work. According to the recent statement of F. J. Robinson, chairman of the commission, these numbers will be considerably increased, since the commission is operating with the municipalities, using municipal equipment, and in general is seeking to turn municipal organization everywhere to the very best advantage.

Dunnville, Ont.—Satisfactory progress is reported at Dunnville on the Erie and Ontario Railway. The right-of-way for this road is 75 feet wide, and the grading now being done is 31 feet from one side, so that if later on the road is double-tracked the two tracks will be in the centre of the right-of-way. The grading is for single track, and the work is being advanced from 3 points,—Smithville, Attercliffe, and Dunnville. The switch from the Michigan Central to the Erie and Ontario has been graded; and the rails are laid on it for the greater part of the distance. Revised tenders for the stations and freight sheds were received recently, and it is expected that the contracts for these will soon be let.

London, Ont.—The major portion of the work on the London breakwater provides for a 3-foot by 2-foot concrete base toe line and a 26-foot natural slope front of embankment faced with reinforced concrete 11 inches thick at the base and 7 inches thick on the top of the slope, where provision is made for a substantial concrete cap and a 5-foot sidewalk with guard tubular iron railing. Short lengths of vertical retaining walls will be necessary at the Oxford and Blackfriars bridge ends of the breakwater. The proposition is to provide for a top area of embankment, giving provision for a driveway, and utilizing existing conditions without disturbing trees or making excessive filling necessary in fixing face line of embankment. The estimated expenditure, as authorized, is $25,000.

Empress, Alta.—The construction of the large bridge which the C.P.R. company is erecting across the Saskatchewan river 6 miles east of Empress is nearing completion. All of the 36 massive piers have been completed. The contract for the steel work on the structure is held by the Canada Bridge Company, and the steel material is arriving at the site. The company commenced work however, on August 31st; and it is expected that the bridge will be entirely complete by October 15th, and that the new C.P.R. line will be connected from Swift Current to Bassano. The ballasting of the line is nearly completed to the bridge, both from the east and west, and it is expected that a train service will be established at an early date the full length of the new line.

Montreal, Que.—A recent important announcement from the headquarters of the G.T.P. system is to the effect that a through passenger and freight service would be put in operation the third week of September between Fort William, Ont., and Price Rupert, the Pacific terminus of the line. The line from the head of the Great Lakes at Fort William to Winnipeg and Edmonton has been in operation for some time. Trains have also been operated westward from Edmonton to Prince George, a distance of 486 miles, and from Prince Rupert eastward to Priestly, a distance of 335 miles. A gap of 131 miles between Priestly and St. George remained unfinished. The laying of the steel was actually completed in April last; but aiming at absolute safety and efficiency, the opening of the system was delayed until the present time.

Fenelon Falls, Ont.—The new dam which has been under construction by the Dominion Government just below Fenelon Falls, and has been supervised by Mr. Alex. Spence and erected by Messrs. McPhee and Kehoe, of Brechin, is now almost complete, and will soon take the place of the old wooden structure which has served at that point for many years. The length of the new dam is 325 feet between the abutments; and consists of 12 large piers, with grooves in either side, for holding the stop-logs. A platform runs from end to end above the sluices connecting the piers; and both platform and piers are built entirely of reinforced concrete. On the platform a track is laid for the purpose of conveying the machinery necessary for adjusting the stop-logs. In the construction of the dam about 2,000 barrels of cement and 2,500 cubic yards of gravel were used. Altogether $47,000 has been granted for the work by the Government; but with the improvements on the original plans and other necessary expenditures above the estimates the total cost will doubtless be $55,000.

PERSONAL.

Lieut.-Col. Hon. J. S. HENDRIE, of Hamilton, has been appointed Lieutenant-Governor of the Province of Ontario, succeeding Sir John Gibson.

R. M. MILAN, of Saskatoon, has been appointed electrical superintendent of the Dominion Government interior storage elevator at Moose Jaw. He will have charge of both installation and operation.

DR. G. G. NASMITH, director of the civic laboratories at Toronto, Ont., has been appointed advisory officer on sanitation to the Canadian expeditionary force, and is leaving Valcartier this week with the first contingent.

BOARD OF HEALTH APPROVES.

During the week ending Sept. 19th the Provincial Board of Health of Ontario approved of the waterworks extensions for the town of Smith's Falls, and of the construction of sewers in Smith's Falls and York Township.

W. H. ELLIS, M.A., M.B., ACTING DEAN OF ENGINEERING, UNIVERSITY OF TORONTO.

The Faculty of Applied Science and Engineering of the University of Toronto resumes activities this week under the direction of William Hodgson Ellis, M.A., M.B., as acting Dean, thereby temporarily filling the vacancy occasioned by the death of Dr. John Galbraith on July 22nd.. Dr. Ellis' appointment to the head of the faculty council comes after a maximum period of connection with the institution, which, until 1906, had been known, since its organization in 1878, as the School of Practical Science. In fact, in the earlier seventies he was a member of the staff of the College of

W. Hodgson Ellis, M.A., M.B.

Technology, the prototype of the institution. In 1878 he became assistant to the Professor of Chemistry, Dr. H. H. Croft. Later, he assumed the professorship in Applied Chemistry.

VICTORIA BRANCH, CANADIAN SOCIETY CIVIL ENGINEERS.

The Victoria branch of the Canadian Society of Civil Engineers recommenced its activities by a meeting on Sept. 17th. Committees were appointed and a program for the season's work discussed. On Sept. 19th the members of the Branch paid a visit to the works of the Pacific Lock Joint Pipe Company at Cooper's Cove, where pipe is being manufactured for the Sooke Lake water supply system.

BURRARD TUNNEL AND BRIDGE COMPANY.

At the annual meeting of the Burrard Tunnel and Bridge Company, of Vancouver, held early last month, officers of the previous year were re-elected. The standing committees are also the same as last year. The company was formed to undertake the construction of the Second Narrows Bridge across Burrard Inlet for details respecting this work the reader is referred to *The Canadian Engineer*, August 27th, 1914, issue. The board of directors of the company is as follows: President, Mr. F. Carter Cotton; vice-president, Reeve May, North Vancouver, and Messrs. Woodside, Loutet, Bridgeman and Vance, with the mayors of Vancouver city and North Vancouver, and the reeves of North Vancouver municipality and West Vancouver, members ex-officio.

CANADIAN GAS ASSOCIATION.

Last week the 7th annual convention of the Canadian Gas Association was held in Ottawa, about 150 representatives of gas plants throughout the Dominion being present. The following officers were elected for the ensuing year: President, H. E. Mann, Chief Engineer, Montreal Light, Heat and Power Company; first vice-president, R. A. Wallace, Manager Quebec Railway, Light, Heat and Power Company; second vice-president, J. M. H. Young, Manager London Gas Company. Executive Committee— A. A. Dion, General Superintendent Ottawa Gas Company; Arthur Hewitt, General manager Consumers' Gas Company, Toronto; Mayor Samuel Carter, Guelph; J. P. King, Manager Stratford Gas Company.

The next convention will be held in Montreal.

C.G.E. CORPS OF ENGINEERS.

In our issue of last week mention was made of the corps of engineers established by the Canadian General Electric Company for service at Quebec, Halifax and Esquimalt. We are able in this issue to reproduce from a photograph taken prior to their departure. Reading from the left, they are:—

Back Row, Standing—H. S. Elliott, Charles Stewart, C. Pink, W. J. Swanger, F. G. Jackson, H. Williams, E. S. Shill.

Front Row, Standing—Capt. Ritchie, A. T. McLean, W. S. Johnson, J. S. Dunlop, G. Hillier, C. Henry, George Monaghan, A. Hardie, J. C. Munro, C. C. Rous.

Front Row, Seated—P. Foster, E. Crockford, H. S. McKean, A. J. Palmer, R. W. Nurse, H. Calvin, R. Lethune, H. Bestard.

COMING MEETINGS.

MOTOR TRUCK CLUB OF AMERICA.—Annual Convention, Detroit, Mich., October 7th to 9th. President, George H. Duck, New York City.

GULF AND INTEROCEAN NATIONAL HIGHWAY ASSOCIATION.—October 8th, 9th, 10th; conference to be held at New Orleans, La. Secretary, Jno. B. Kent, Lake Charles, La.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.—Annual Convention, Grunewald Hotel, New Orleans, La. October 20th to 23rd. Secretary, Mr. McFall, Roanoke, Va.

ALABAMA GOOD ROADS ASSOCIATION.—Nineteenth Annual Convention will be held from October 21st to 23rd at Montgomery, Ala. Secretary, J. A. Rountree, 1021 Brown Marx Building, Birmingham, Ala.

NORTHWESTERN ROAD CONGRESS.—Annual Convention, to be held at Milwaukee, Wis., October 28th to 31st. Secretary, J. P. Keenan, Milwaukee.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Charles Carroll Brown, Secretary, Indianapolis, Ind. Meets at Somerset Hotel, Boston, Mass., October 21st, 22nd and 23rd.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

WASHINGTON STATE GOOD ROADS ASSOCIATION.—Convention to be held at Spokane, Wash., November 18th, 19th, and 20th. Secretary, M. D. Lechey, Alaska Building, Seattle, Wash.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.

The Robert W. Hunt and Company, Limited, has removed its Vancouver, B.C., office and cement and physical testing laboratories from the Bank of Ottawa Building to the Standard Bank Building, 508 Hastings Street West.

Volume 27. Toronto, October 8, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

POWER DEVELOPMENT AT WASDELL'S FALLS, ONT.

A LOW-HEAD PLANT OF EXTREMELY INTERESTING DESIGN—INITIAL UNDERTAKING OF THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO IN THE FIELD OF POWER PRODUCTION.

THE approaching completion of the plant at Wasdell's Falls will mark the beginning of a new epoch in the history of the Ontario Hydro-Electric Commission, meaning as it does the entry of the Commission into the field of actual power production at cost as an adjunct to the policy of cost price transmission and distribution heretofore pursued.

The result of this expansion of policy in the present instance will be that connected consumers will derive the utmost economic benefit which can result from the development of a water-power.

The development project arose out of the necessity of meeting requests from a number of municipalities on the east shore of Lake Simcoe to be supplied with power through the Commission, investigation having indicated conclusively that the Wasdell's Falls site was the only source of power from which the present and immediate future needs of this district could be adequately supplied. Following the receipt of signed contracts from five of the municipalities involved, covering the supply of about 625 h.p., plans and specifications were prepared and authority to proceed with the work was obtained from the Provincial Government.

Natural Conditions.—Wasdell's Falls is located on the Severn River, about three miles below the outlet of Lake Couchiching. Owing to backwater effects the natural head was subject to considerable variation throughout the year, ranging from about six feet at extreme high water to ten feet at low water. It was determined, however, that with the forebay levels which would result from development, the head under the worst anticipated backwater conditions would never be less than 9 feet. Similarly the maximum head was determined to be 15 feet. Apart from the low head, the topographical conditions at Wasdell's Falls are most favorable for development, and the solid granite formation on which the works are founded has nowhere developed serious faults or fissures.

The drainage area of the Severn River above Wasdell's Falls is about 2,075 square miles. About 700 square miles of this area is included in the basin of the Black River, which joins the Severn about midway between Wasdell's Falls and Lake Couchiching, while the remaining 1,375 square miles of watershed is practically all tributary to the immense storage basin of Lake Simcoe, 297 square miles in extent.

Fig. 1 (left) View of Wasdell's Falls Power House, Showing High-tension Line Outlets. Fig. 2 (right) View Showing Dam.

The maximum discharge of the Severn River at Wasdell's Falls, as so far determined by gauge records and discharge measurements, is 9,050 sec.-ft., which is equivalent to a run-off of 4.36 sec.-ft. per square mile of watershed. The minimum flow, 260 sec.-ft., is equivalent to a run-off of .13 sec.-ft. per square mile, and the average flow for 1913, 2,489 sec.-ft., corresponds to a mean annual run-off of 1.2 sec.-ft. per square mile.

Other figures relative to the flow characteristics of the river are shown in the following table:

Table I.—Monthly Discharge of Severn River at Wasdell's Falls for 1913.

Month	Discharge in second-feet Maximum	Discharge in second-feet Minimum	Discharge in second-feet Mean	Discharge in second-feet Per square mile Maximum	Per square mile Minimum	Per square mile Mean	Run-off Depth in inches on drainage area
Jan. ..	4,840	1,840	2,419	2.33	.89	1.17	1.30
Feb. ..	3,120	2,050	2,432	1.51	.99	1.17	1.26
Mar. .	8,785	1,640	4,231	4.24	.79	2.04	2.42
Apr. ..	9,050	5,600	7,790	4.36	2.70	3.76	4.20
May ..	5,525	3,375	4,175	2.66	1.63	2.01	2.32
June ..	3,375	2,225	2,680	1.63	1.07	1.29	1.44
July ..	2,200	1,175	1,644	1.06	.57	.79	.91
Aug. ..	1,075	800	937	.52	.39	.45	.52
Sept.. .	1,025	700	815	.49	.34	.39	.43
Oct. ..	875	260	570	.42	.13	.27	.31
Nov. ..	1,475	450	897	.71	.21	.43	.50
Dec. ..	1,505	905	1,276	.73	.44	.62	.73
Total..	9,050	260	2,489	4.36	.13	1.19	16.43

It may be mentioned that some doubt attaches to the figures for minimum flow as shown in Table 1. owing to the extremely low velocities which obtained at the metering station during periods of very low water. The actual minimum discharge is doubtless somewhat greater than indicated above, but in the interests of safety the figures relative to minimum flow have been left exactly as recorded.

The dams now being constructed at the outlet of Lake Couchiching in connection with the Trent Canal project will make available at least 12 inches depth of storage on Lake Simcoe. Properly regulated flow from this storage alone would meet the maximum requirements of the Wasdell's Falls plant for a period of six months in any ordinary dry year, while the records to date show that the period of deficient flow in an abnormally dry year is not of more than three months duration.

Permanent Works.—The dam is of the pier and stop-log type with six 14-foot sluices and a central overflow section 25 feet long which can be used during the high-water periods for driving logs. This section of the dam is closed by vertical needles, which will sustain a head of about 4 feet at maximum headwater level. When wide open, the dam can safely pass a discharge of 15,000 second-feet.

The power-house foundations, including inlets, wheel-chambers and draft tubes, are of mass concrete, only the wheel-chamber and generator arches and a portion of the draft-tube arches being reinforced. The whole of the superstructure, including the roof and crane-girders, is of reinforced concrete. The panel sections between the main columns consist of two layers of hy-rib reinforcement so placed as to provide a 4-inch air-space. The outer layer is plastered with a 2-inch coat of 1 : 2½ cement mortar and the inner layer with a coat 1¼ inches thick. The forebay walls, and the partition wall between the generator room and the forebay, consist of a single coat of plaster 2½ inches thick laid on hy-rib. The hy-rib was set in 2-inch checks left in the columns and girders and was further supported by light 4-inch channels set vertically in the air-space on 5-foot centres.

The wheel-chamber inlets are divided by a centre pier and in each of the four openings is placed a wooden head-gate spanning a clear waterway of 12 feet 1½ inches. These gates are built of 8-in. x 8-in. and 8-in. x 10-in. yellow pine, and in one gate of each pair is placed a 16-in. x 16-in. wicket gate for filling the wheel-chambers. The head-gates are not intended to be opened under full static pressure under normal conditions, although the operating mechanism is sufficiently powerful to admit of such operation if necessary.

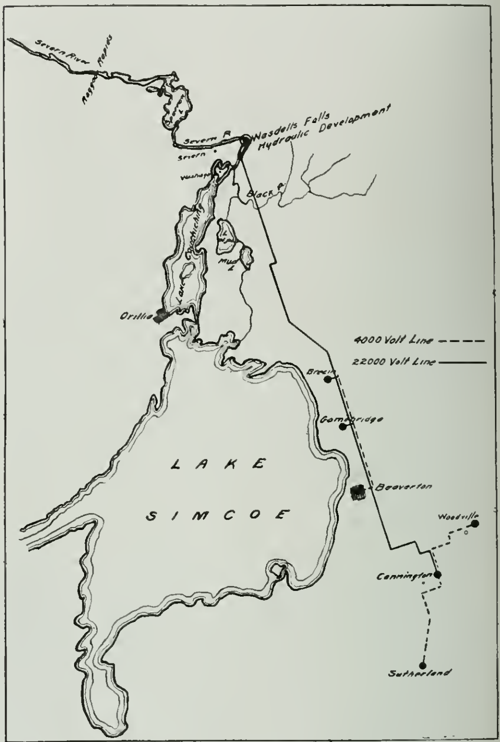


Fig. 3.—Location of Development on Severn River and Main Transmission Lines.

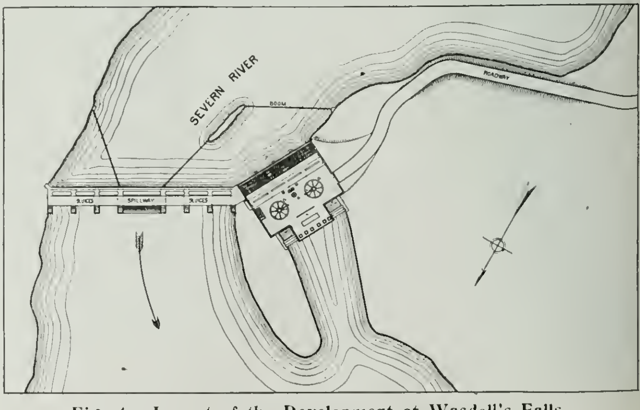


Fig. 4.—Layout of the Development at Wasdell's Falls.

As will be seen in the accompanying illustrations, the racks are entirely enclosed, making it possible to exercise a certain amount of control over rack temperature as a means of coping with frazil trouble.

It will also be noticed that the forebay curtain wall is located approximately parallel to the natural stream lines, so that by opening the sluices next the power-house,

Fig. 5.—Racks and Head Gate Mechanism.

a deflecting current can be utilized to clear the outer forebay of debris, floating ice and frazil.

Hydraulic Equipment.—The hydraulic equipment was manufactured and installed by the Boving Company of Canada, Limited, having comprised the first order filled from the company's new plant at Lindsay, Ontario. The two main units are of the vertical, double-runner, mixed

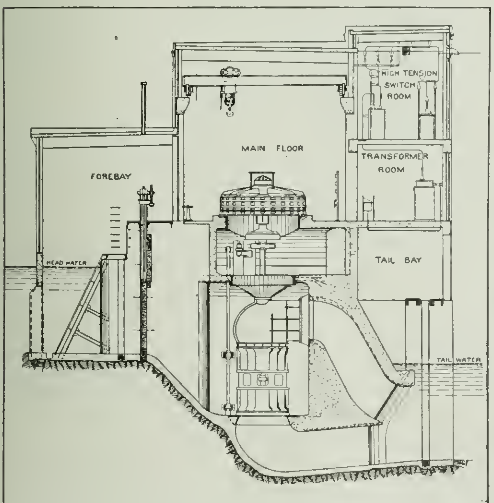


Fig. 6.—Cross-Section Through Power House.

flow, open flume type with separate draft-tubes, and are designed to operate at best efficiency under a 12-foot normal head, at 90 r.p.m. Under normal head, each unit has a guaranteed three-quarter gate capacity of 600 b.h.p. and a full gate capacity of 500 b.h.p. under a 9-foot head. The guaranteed efficiencies for ½, ⅔, ¾, ⅞ and full gate are 75, 80, 83, 85 and 80 per cent. respectively, at 12-foot head. Maximum output, and not efficiency, is the governing factor under low-head conditions, owing to the abundant supply of water then available.

The exciter turbine is of the same general type as the main units, but has a single runner only. It is designed

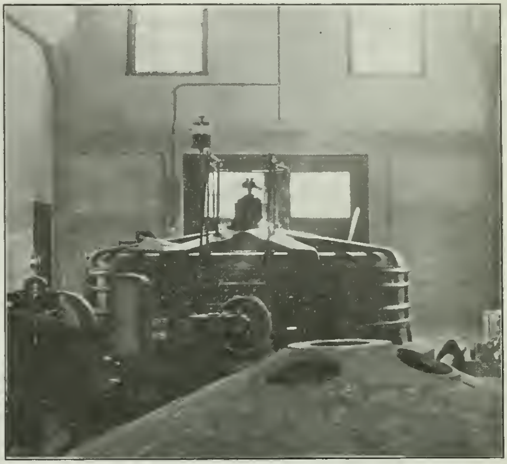


Fig. 7.—Main Generator.

primarily to produce sufficient power for full plant excitation under an 8-foot head. The operating speed is 190 r.p.m. and the ¾ and ⅞ gate efficiencies under normal head are 81 and 83 per cent. respectively.

The governors of the main units are of the self-contained oil pressure type, with a hand regulating attachment. Each governor is provided also with an electric servo-motor which enables the operator to make speed adjustments from the switchboard.

Fig. 8.—Erection of No. 1 Generator. The View Also Shows the Shaft and Lower Runner of No. 2 Turbine.

The governors are adjusted for 1½ seconds closing time and will handle a momentary fluctuation of 25% of full load with a speed variation not exceeding 6½ per cent.

Electrical Equipment.—The main generators and exciting equipment were manufactured and installed by the

Swedish General Electric Company. The equipment supplied under this contract comprised two main generators each of 400 k.v.a. capacity, vertical water-wheel type, 3-phase, 60-cycle, 2,300-volt, 90 r.p.m.; one 20-kw., 125-volt, 190 r.p.m. direct current water-wheel type exciter generator; and one 30-kw. motor generator set.

The total revolving weight of the main generators and exciter is carried on specially designed ball thrust bearings mounted on the top of the generator frame, and connection is made to the turbine shaft by means of flexible couplings.

The transformer and switching equipment was supplied by the Canadian Westinghouse Company. The present transformer installation consists of three single-phase, 60-cycle, 150-k.v.a., oil-insulated, self-cooling transformers wound for 1,900 to 2,500 volts on the low-tension and for 22,000 to 25,006 volts on the high-tension side, both sides being connected in delta. One spare transformer is also supplied.

In the high-tension switching gallery are located two 25,000-volt, 3-pole, remote control oil switches, the high-tension busses, two 25,000-volt electrolytic lightning arresters, and a choke coil on each outgoing line.

Auxiliary Equipment.—The stop-log winch was installed by the Wm. Kennedy Company, of Owen Sound, being their No. 1 type of 17 tons capacity. This winch is at present arranged for hand operation, but is so designed that a motor drive can be added at any time. The head-gate operating mechanisms were also supplied by the Kennedy Company.

Fig. 9.—Crane Girders and Hy-rib Reinforcement Previous to Plastering.

A 10-ton hand-operated travelling crane has been installed. This was supplied by the W. D. Beath Company, of Toronto, as was also a 1-ton trolley block which travels on an I-beam hung from the forebay roof girders, and is used for handling the racks.

Personnel.—The development was officially opened on Tuesday, October 6th, by Sir Adam Beck, chairman of the Hydro-Electric Power Commission of Ontario. Mr. F. A. Gaby is chief engineer to the Commission; Mr. H. G. Acres, hydraulic engineer; and Mr. E. T. Brandon, electrical engineer.

At the present time there are in India 2,331 miles of railway in course of construction or planned for construction during the year 1914-15. Of this total 1,575 miles are already under way and 856 miles are merely proposed. Of the former 220 miles are being constructed by the state and 1,355 miles by private companies. Of the latter, 173 miles will be constructed by the state and 583 miles by private companies. The total cost of the 2,331 miles of line is estimated at $80,000,000.

Steel railroad ties are being extensively used in Switzerland. At present 65 per cent. of the Federal railways employ them. They have the form or profile of a trough into which shape they are rolled at the mills. The ends are bent down, the profile of the trough being thus closed. Holes are provided for the attachment of the rails by means of clamp plates, and no tie-plates are used under the rails. The weight of the trough profile is 55.47 lbs. per metre; and the ties complete, with holes bored, weigh 159.84 lbs. each. According to the requirements of the Federal railways the steel in these ties must have a tensile strength of about 59,000 to 64,000 lbs. per sq. in., and an entire trough piece shall admit of being bent together on its back without showing any breaking fissures.

Pittsburgh manufacturers have received numerous inquiries for prices on all kinds of steel. The inquiries have come for the most part from England, Japan and South America. The announcement made recently that manganese would be manufactured in the United States to offset the closing of European ports was a welcome one to manufacturers generally. Pittsburgh firms now say that their production of steel will not be hampered by the war.

R. D. Featherstonhaugh, mining engineer, reports that he has filed for the Omenica Exploration Syndicate of the Tegler Building, Edmonton, silver claims that will produce 600 ounces of metal to every ton of ore. Mr. Fetherstonhaugh has staked 5 dredging leases for the concern, these being 15 miles on the Omenica River, 5 miles on the Findlay River, and 3 miles on the Ospica River. Three copper and silver claims were also filed at Lake Tacla; 10 mineral claims on Mount Selwyn, located off the banks of the Peace River. According to the engineer, the latter promises to develop into an important and extensive proposition. Anthracite coal claims were also filed upon by Mr. Featherstonhaugh for the Edmonton syndicate, which are so rich that samples have proved to contain 90 per cent. carbon, the richest of the reported anthracite coal claims in the west.

INFORMATION RESPECTING PATENTS OF INVENTION.

A FEW weeks ago a reader of this journal favored us with some useful information as to the position of an applicant for the patent, or a patentee, who has volunteered for active service and is thus unable to attend to the prosecution of his case.

It is generally known that in all patent offices certain rules are laid down restricting the length of time in which certain documents may be filed, renewal fees paid, and so on.

In Great Britain, he stated, an act has now been passed under which the comptroller of patents has the authority to grant extensions of time for the filing of such documents, the duration of such extensions being governed by the particular conditions of the case. This provision is made for the benefit of applicants or patentees who are absent from their country on active service or for any other justifiable reason are prevented from attending to their cases by circumstances arising from the present state of war.

The extension may be also granted when it is shown that the documents could have been filed, but under the circumstances arising from the state of war this would be prejudicial to the rights or interests of the applicant or patentee.

"The provisions apply only to patents in Great Britain and it remains yet to be seen whether a similar act will be passed in Canada and other British possessions.

"The British Patent Office has also made arrangements regarding documents intended for countries at war, in which the lodging of documents may be difficult. These documents should be filed through the British Patent Office, when the comptroller will date-stamp them and retain until such time as conditions would make it safe to forward to their destination. By this means, official evidence will be shown that the papers were duly executed and forwarded for filing on specified dates. Foreign renewal fees, etc., may also be paid in a like manner."

A copy of a special Act which has been passed to govern conditions due to the present trouble in Europe, and applying to patents in Canada, has since been received. Its principal clauses are as follows:

Orders and Regulations respecting patents of invention, made under the "The War Measures Act, 1914."

1. "Commissioner" means Commissioner of Patents and includes the Deputy Commissioner of Patents.

2. The Commissioner may, on the application of any person, and subject to such terms and conditions, if any, as he may think fit, order the avoidance or suspension, in whole or in part, of any patent or license, the person entitled to the benefit of which is the subject of any State at war with His Majesty, and the Commissioner, before granting any such application, may require to be satisfied on the following heads:—

(*a*) That the person entitled to the benefit of such patent or license is the subject of a State of war with His Majesty;

(*b*) That the person applying intends to manufacture or cause to be manufactured, the patented article, or to carry on, or cause to be carried on, the patented process within the Dominion of Canada;

(*c*) That it is in the general interests of the country or of a section of the community, or of a trade, that such article should be manufactured or such process carried on as aforesaid.

The fee payable on such application shall be ten dollars.

The Commissioner may at any time, in his absolute discretion, revoke any avoidance or suspension of any patent or license ordered by him, but if any person during the period of such avoidance or suspension begins to manufacture, use or sell in Canada the invention covered by said patent, such person may continue to manufacture, use or sell such invention in as full and ample a manner as if such revocation had not been made.

Provided always that the Commissioner may at any time, if in his absolute discretion he deem it expedient in the public interest, order the avoidance or suspension in whole or in part of any such patent or license upon such terms and conditions, if any, as he may think fit.

3. The Commissioner may, at any time during the continuance of these Orders and Regulations, avoid or suspend any proceedings on any application made under the Patent Act by a subject of any State at war with His Majesty.

4. The Commissioner may also, at any time, during the continuance of these Orders and Regulations, extend the time prescribed by the Patent Act or any rules made thereunder, for doing any act or filing any document, upon such terms and subject to such conditions as he may think fit in the following cases, namely:—

(*a*) Where it is shown to his satisfaction that the applicant, patentee, or proprietor, as the case may be, was prevented from doing the said act, or filing the said document, by reason of active service or enforced absence from this country, or any other circumstances arising from the present state of war, which, in the opinion of the Commissioner, would justify such extension.

(*b*) Where the doing of any act would, by reason of the circumstances arising from the present state of war, be prejudical or injurious to the rights or interests of any applicant, patentee or proprietor as aforesaid.

Such extension of any prescribed time, if granted after its expiration, shall have the same effect as if granted prior thereto, provided such expiration occurred on or after the fourth day of August, 1914.

5. The Commissioner may refuse to register the assignment of any patent made by a subject of any State at war with His Majesty, and filed in the Patent Office on or after the fourth day of August, 1914, unless satisfied that such assignment was made in good faith and not for the purpose of evading any of the provisions of the foregoing Orders and Regulations.

CEMENT USED IN TURKEY.

Cement is scarcely known in Turkey, but very good results are said to be given by a substitute consisting of slaked lime, linseed oil, and cotton fiber. The oil being poured on a small quantity of cotton and the lime dusted in, the mixture is kneeded thoroughly. The dough-like mass is used for filling crevices in water-pipes, covering cracks in stone floors, and for various other purposes. The material resists water, though it must be thoroughly dry before submerging.

The Taghum bridge, an ordinary type steel highway bridge over the Kootenay River, about five miles from Nelson, B.C., has recently been completed. The structure consists of three steel truss spans and two girder spans, supported on concrete piers and abutments. The bridge was designed by the Public Works Department of the Province of British Columbia and was erected for the Government by Hodgson, King and McPhalen Brothers, of Vancouver, at a cost of approximately $100,000. On account of difficulties in erecting the falsework, occasioned by the swift current of the river, so much time was lost in the early stages of the work that the contractors were obliged to employ three shifts of eight hours each in order to complete the structure before the coming of the spring freshets.

WIRELESS STATION AT NEWCASTLE, N.B.

THE most powerful wireless station in the world is just being completed at Newcastle, N.B. Its main tower is 500 ft. in height and is surrounded by six 300-ft. auxiliaries. The antenna forming the network around these towers comprise 120,000 ft. of silicon bronze wire, while over 140,000 ft. of wire have been laid in trenches around the station to secure proper ground connections. The operating house is at the base of the main steel tower, while the power house is situated outside of the line of towers. The latter is equipped with two 225 h.p. motors direct connected to two 1,000-volt d.c. generators. The total cost of the station is about $175,000. The sending and receiving instruments which are of the type known as the Poulsen System, were manufactured in Copenhagen, Denmark. The distance across the Atlantic to the corresponding station at Ballybunion, Ireland, is about 2,700 miles.

It may be stated that among wireless systems now in use are the Marconi, Poulsen, Goldschmidt, Lodge-Muirhead, Slabyarco, Braun-Sienens-Halske, Braney-Popp, Rochefort, Dueretet Popoff and the Guarini.

The system used in Newcastle was invented in 1905 by Dr. Poulsen, a Danish scientist, and while fundamentally like the other systems, differs materially in many essential features. The Marconi system makes signals by closing and breaking on electric circuit. Every dot and dash signal represents an independent electric current impulse transmitted through the air. The Poulsen system makes signals by varying—at the will of the sending operator—the electric wave length in a continuous current. The Marconi system opens the line of transmission for each separate signal. The Poulsen system opens the line once and keeps it open by continuous electric impulses, while the signals are being transmitted.

In the Marconi system, the question whether these intermittent waves sent out reach a certain point depends upon the energy of each initial impulse. In the Poulsen system the waves not all preserve their original form, but as the energy is being sent out constantly, one wave reinforces the other. This system operates night and day with the same efficiency, sunlight having very slight effect on transmission. A drawback to which other systems are subject is their efficiency—as far as distance is concerned—is three or four times greater at night than in the day time. Stations that can reach a ship 1,000 or 2,000 miles at night cannot reach over 200 or 300 in the day time. This is caused by the electrification of the ether by the sun's rays, which presumably makes it more difficult for the artificially created waves to travel through the ether, and also causes a greater absorption of energv by the earth.

Duplex sending and receiving have been accomplished by this system, which means that two messages can be sent or received by the same antenna simultaneously.

The commercial speed expected from the wireless station at Newcastle is 150 words a minute, while the greatest speed worked by cables across the Atlantic is 50 words a minute.

The Washington bureau of statistics of the American Iron and Steel Institute gives the production of all classes of ingots and castings in Canada in 1913 as 1,042,503 tons, an increase of 189,472 tons over the previous year. All kinds of finished rolled iron and steel produced are placed at 867,097 tons against 861,224 tons the year before. Pig iron production in Canada for the first six months of 1914 is placed at 442,430 tons against 469,137 tons for the last half of 1913.

PAVEMENT ECONOMY.*

THE economical pavement is a subject of much discussion, but like the proverbial fountain of youth it still remains undiscovered. Many claims have been made for the different types of pavements on the market and almost any promoter, material man or contractor, believes that he can, if given the proper amount of time, convince you that his is the only economical pavement. The truly economical pavement is the one best suited to meet the local conditions which will withstand the ravages of time and traffic with the least possible maintenance, first cost considered.

The old Roman roads with their foundations two or three feet, and in some cases as much as six feet in thickness, were economical roads and pavements for their time, for they not only met the conditions of their time, but have stood the traffic of centuries. To build a Roman road in modern times, however, would not be economical or wise. An administration attempting to lay a Roman road would probably not only start a vigorous protest of abutting property owners but would find a quick demand for a change in administration. While the history of the old roads of the Roman Empire, France and England, is interesting and they have been of great service in the development of modern type of pavements, they can no longer be used as models.

Americans, with their nervous, progressive and energetic spirit, must solve their own paving and road problems to meet their own particular conditions.

The principal considerations in determining the economical pavement are the traffic and climatic conditions to which the pavement must be subjected, available materials and their cost, assessed valuation of abutting property, and the probable result of the improvement.

Before a pavement is laid the climatic and traffic conditions should be given most serious consideration and should be a big factor in making the final determination. In the large cities where traffic is heavy, granite or wood block are very largely used. This is because these two types of pavement have been found to withstand heavy traffic more satisfactorily. Where the question of excessive noise is not material, the long life and small difference in cost, and the ease of repairs and low cost of maintenance, make granite block the favorite; while on a heavy traffic street lined with office buildings or stores, where the question of noise must be taken into consideration, wood block is constantly increasing in favor. It would be folly indeed to lay a concrete pavement, bituminous or water bound macadam, or any other cheaper type of construction under such conditions. In considering the traffic conditions to which a pavement must be subjected, it is always necessary to take into consideration the probable increase in traffic after the pavement has been laid, and in many instances it is advisable to take traffic census for the proposed improvement. It is not uncommon for the traffic of a road or pavement to double in volume after the improvements are made.

Another very important matter in considering the traffic conditions, is the kind of traffic. Where horse-drawn traffic prevails, a pavement should be made to aid this class of traffic; and where motor traffic prevails, a different type of pavement entirely may prove to be the most economical. Probably one of the best examples of

* Notes from a paper read by H. B. Pullar, Engineering Chemist, Detroit, before a recent meeting of the League of Michigan Municipalities.

this kind can be cited in Wayne County, Michigan. Almost everybody interested in paving has heard more or less favorable comments as to this large mileage of concrete roads. The traffic on the Wayne County roads has been reported as being over 80 per cent. motor traffic, and a large per cent. of this motor traffic is pleasure vehicles. The roads are and have been constructed by the most up-to-date methods and repairs are made immediately any defects appear. Were these conditions reversed, and the concrete roads in Wayne County compelled to withstand over 80 per cent. of horse-drawn traffic or even a much higher per cent. of heavy commercial car traffic, they would probably not prove to be the most economical, and the reported low cost for repairs and maintenance would be considerably increased.

Climatic conditions should be given consideration when determining upon the most suitable type of pavement. In England it was found that asphalt pavements laid similar to those in America deteriorated rapidly, and the cause was found to be the heavy fogs. A higher percentage of asphalt was used to overcome this trouble and more successful results were obtained. The southern part of this country requires a bituminous material of different consistency than that used in the northern section.

Bituminous pavements to give most successful results must have suitable drainage, and while this is true of other pavements it is specially true of all bituminous work. The climatic conditions of Michigan permit the use of many and various types of pavements, and they are not as important a matter as in other parts of the country.

The availability of materials is often given but slight consideration in determining the type of pavement to be constructed, and yet it is of the utmost importance in some localities. Where good sand is available at a low cost and where other conditions are equal, how foolish it is to import brick from another state in preference to laying sheet asphalt pavement, which is composed of about 80 per cent. of sand, whereas the reverse would be true if it were necessary to import sand into a town in which there is a brick plant turning out high quality brick. There are conditions in different cities which make it advisable, even at a much higher cost, to favor one type of pavement over another, but where the truly economical pavement is desired and other conditions are equal, the availability of materials should be given careful consideration.

In determining the most economical pavement the assessed valuation of the property is too often considered to be of minor importance, and politics and real estate promoters are frequently the cause of sheet asphalt pavements being laid out in the country, while the old unreliable water-bound macadam pavement remains in the heart of the city. We find many instances where wooden block pavements are laid on light traffic residence streets with heavy assessments made against the abutting property owners, who can ill afford them, while in the main business strees a cheaper type of construction is used with a heavy maintenance coming out of the general taxation fund. This practice is certainly contrary to all ideas of economy, and there has been much waste of public funds in cities where such conditions exist. A careful consideration of the needs of a street and the assessed valuation of the abutting property will not only result in better streets, but will cause a much lower general maintenance charge on all paving in the city and a more equal and just distribution of the paving fund.

The medical profession, with its great scientists and students, is continually finding new cures for what have been previously considered incurable diseases. Likewise the engineering profession, by its scientific studies and research work, will continue to overcome the numerous and difficult problems of paving construction. The economical type of pavement is distinctly an engineering problem and its solution for any particular street or locality will depend upon the efficiency of your engineer. The time is coming when the city engineer will be given more authority to direct and more opportunity to study and work out to advantage his paving problems. A successful manufacturer would soon lose his business and turn his dividends into losses were he to employ a new superintendent each year; as he would, also, if he should employ a capable superintendent to look after his business and then only spasmodically assist him in his work, or fail to give him authority to go ahead. So the choice of the economical pavement must be left with a capable engineer, receiving a big compensation and with full authority to direct his work, and in this he should receive the co-operation and help of all officials and citizens.

While I have endeavored to give you a general idea as to some of the important features to be taken into consideration when deciding upon the economical pavement for your city or town, I will endeavor to give you a short description and history of what we believe to be one of the coming types of economical bituminous construction. This is known as the open type of asphalt or bituminous concrete.

With the advent of the automobile and the demand for a more permanent type of construction than the water-bound macadam, the bituminous macadam laid by the penetration method was one of the first to be considered and has been most extensively used. For a time it seemed to have solved the problem, but failures have been too frequent and costly. While there are many good bituminous macadam roads which were constructed by the penetration method, the many small details which must be carefully looked after in order to get successful results have made the proportionate chances of failure so numerous that it is always with more or less uncertainty of results that a penetration job is constructed. The principal causes of the failure of bituminous pavements laid by the penetration method are the impossibility of thoroughly coating each particle of stone and the segregation of the stone, making it impossible to obtain an even distribution of the bituminous material. The result of this is that there are numerous spaces in the road which allow water to penetrate, causing the pavement to disintegrate rapidly.

Another type of bituminous pavement which has found great favor, is the bituminous concrete, which is a mixture of asphalt, sand and stone. This type of pavement would find greater favor were it not for the fact that certain patents to cover practically all mixtures of stone and sand have been held valid in some of the courts; and on account of the undesirability of getting into any patent litigation cities have hesitated in adopting this type of construction.

Because of the uncertainty as to the results obtained from the penetration work and because of the desirability of getting a cheaper type of bituminous pavement than the asphaltic concrete or sheet asphalt, the open type of asphaltic or bituminous concrete has been developed and has met with much favor in different sections of the country. This type of pavement, however, is not a new one, having been used many years ago with a tar binder. The pavement consists of a mixture of stone and bituminous cement acting as a binding medium.

The stone is heated to a suitable degree of temperature, depending upon the bituminous material used, and then mixed with bituminous binder in suitable proportions. It is laid similar to sheet asphalt or asphaltic concrete. The mixture is laid from 2 to 3 inches in thickness and properly rolled. After rolling there is applied a squeegee coat of pure asphalt cement and while the coating is still hot stone chips are thrown over the surface. The whole pavement is then re-rolled so the squeegee coat is forced into the voids, making a tight, uniform, waterproof and durable surface. Heating the stone and then mixing in asphalt so that each particle is thoroughly coated, prevents the trouble which causes so many failures in the penetration method and prevents any segregation of stone.

The city of Lansing last year tried out this type of pavement on some of the principal streets with excellent results at a very low cost. On account of the results obtained the State Highway Department of Michigan will put in a strip of this same type of pavement in Oakland County, which is an extension of the Woodward Avenue pavement of Detroit. This section of pavement will join the concrete road of Wayne County and will afford an excellent opportunity for a comparison of the two different types for the same traffic. There are a number of other cities in the state which have already laid considerable yardage of this open type, and which contemplate laying in the future a large amount of this work.

The open type of asphaltic concrete pavement is free from infringing on any patents, thus removing any cause for litigation. Although there are about 35 per cent. of voids in the mix as it comes from the mixer the stones key in together giving the wearing surface stability, thus preventing shoving and rutting. In fact, the finished pavement is similar to water-bound macadam with the exception that each stone is bound together with asphalt cement. The asphalt cement prevents any dislodgement of the stone from either horse-drawn or motor traffic.

The first cost of this pavement is very nominal compared with other types, being slightly higher than that of the penetration and considerably less than the closed type of bituminous concrete or sheet asphalt. With average conditions these pavements can be laid by contractors for from $1.10 to $1.40 per square yard, including 6-inch concrete foundation, but if the pavement is put in by the day labor plan, under the supervision of the city engineer, the cost should be considerably lower. In fact, I believe the total cost of the paving at Lansing did not exceed $1.10 per square yard, and the city used crushed cobble stone instead of limestone, which added considerably to the expense.

The open type asphaltic concrete pavement after traffic has been on it for some time looks almost the same as the closed type, or like bitulithic. It is easy to repair, pleasing in appearance and makes a sanitary and noiseless pavement. There are many cities and towns throughout Michigan, especially in the residential sections, where this type of construction would be advisable. I think it would prove to be the economical pavement and I believe that it will constantly grow in favor with engineers and officials in charge of paving work.

There is another item to be taken into consideration in discussing the economical pavement. No type of construction and no materials, no matter how high the quality or how successful they have been in other places, will be satisfactory in any locality unless they are properly constructed. Just because a pavement or a particular type of construction has given successful results in one town or one locality is no indication that it will be equally successful in your city or town unless every precaution is taken to see that the numerous small but important details are carefully looked after. The best of materials cannot give good results unless properly handled, while better results can be obtained with poor materials properly applied.

It is not, by any means, always economical to award contract to the lowest bidder and a difference of 5, 10, or even 25 or 50 cents per square yard in the original cost may in the end prove most economical.

In conclusion, I would state that the economical pavement of to-day is not any particular type or any particular material, nor is it a pavement put in at any particular cost. It is a pavement carefully selected after an exhaustive preliminary examination by an efficient engineer to best meet the demands of the particular locality in which it is to be constructed. It is a pavement laid in direct accordance with the requirements of carefully prepared specifications, which should be reasonable and just to both the city and contractor. It is a pavement in which only the most suitable available materials for its particular type of construction are used; a pavement laid under the direction of an efficient and capable engineer, with authority to direct and supervise the many details of construction and to appoint inspectors for their efficiency and ability to carry out his orders, rather than for their ability to obtain votes at the next election. The city or town in which this condition exists, while it may continue to have a failure now and then, and while it may not find the one economical pavement, will come nearer to solving the problem and satisfying the taxpayers, to whom all public officials in the end must look for commendation.

WATER RIGHTS LAW PROBLEM.

The American Society of Civil Engineers has recently appointed a special committee, composed of eminent engineers, to ascertain the need for a national water law in the United States to protect existing rights and future engineering developments from interstate difficulties.

The enumeration of possible difficulties, as prepared by this committee, is of interest in Canada, where some of them may exist as interprovincial difficulties. Some of the interstate difficulties may be caused as follows:

1. From taking water across state lines;

2. From the use of water in an upper state which may jeopardize the quantity and quality for use in a lower state;

3. From approximations on border streams where the controlling works are in two states;

4. From the storage of water in an upper state for transit in stream channels through several states and use for navigation, power, etc., at the lower end of the stream;

5. Because of judicial decisions in one state prohibiting the diversion of water from one drainage basin into another, or across state lines;

6. From the construction of unsafe works in one state which menace lives and property in adjoining states;

7. From the drainage of swamps or lakes in one state which removes the natural regulation of flow and which may cause destructive floods in adjoining states;

8. From the pollution of water in one state to the detriment of lower states;

9. Because of international treaties and controversies where state or federal jurisdiction is questionable.

THE MECHANICS OF REINFORCED CONCRETE UNDER FLEXURE IN BEAM AND SLAB TYPES.*

By C. A. P. Turner, M.Am.Soc.C.E.

THE co-operation or combined action of the two materials, concrete and steel, to resist bending, depends solely on the bond between the two. In the case of plain rods this bond is in reality a shrinkage grip which prevents the steel from sliding through the hardened matrix in which it is embedded and the resistance afforded is subject to well-defined laws which may be stated as follows:

The bond shear is zero wherever the tension in the steel is constant. It passes through zero where the increment of the moment passes through a maximum or minimum. It must be depended upon whether the reinforcement is in one direction only as in a beam, or in multiple directions in the slab.

Bond shear generates stresses emanating from the surface of the bars which may be treated as lines of force. These lines of force follow the general laws of distribution of force through any medium; that is, their intensity is inversely as the square of the distance from the surface of the steel on which they are generated.

These general laws enable us to investigate or follow out the part played by bond shear in the mechanics of a slab or beam. In the case of a simple beam, in accordance with the law stated, the intensity of the bond shear is zero at the centre for uniform load and a maximum toward the end of the beam, and it is the bond shear or the lines of force generated thereby to which we may attribute the difference in the failures of an over- and an under-reinforced beam. In the case of the beam with light reinforcement, failure takes place at the centre by the yielding of the steel. With heavier reinforcement, however, failure is more liable to occur toward the end by diagonal tension induced by web stresses, which are greater toward the ends of the beam and which may rupture the concrete across the lines of tension in it. Perhaps the largest part of these web stresses originate in the bond shear at the surface of the reinforcement.

The deportment of the simple beam as affected by the stresses set up by the bond shear is of interest. In a newly cast beam, in the preliminary stages of the loading, the stress in the steel, as determined by the extensometer, is much less than that figured on the assumption that the steel only resists tension. In fact, it is only about one-half as great as we should compute the stress to be on that basis, until the steel is stressed up to four or five thousand pounds per square inch. When this point has been reached there is a rapid increase in the stress in the steel, with no corresponding increase in the load until, when the steel is stressed up to twelve or fifteen thousand pounds per square inch, the concrete has relieved itself of a large portion of its tensile resistance and the measured stress in the steel corresponds closely to the computed stress in the steel, assuming that the steel is not assisted by the concrete in tension.

With the slab reinforced in two directions, however, the phenomenon differs from that observed in the beam. Take for example the case of such a slab, bent in such manner that the rods in both directions are brought into tension at the same time. The indirect stresses generated by the two sets of rods will, under this condition, react upon each other, since the lines of force diverge from each rod they may meet, and coact through the concrete as a medium of transmission of the stress, which is not possible in the beam with one-way reinforcement, since in the beam these stresses cannot coact with each other, there being one kind only, and not two kinds acting in different directions. This fundamental difference in the induced stress generated by the bond shear in the case of a beam and slab render the two types of structure mechanically different, and necessitates their treatment in a manner which takes into consideration the difference in the mechanical operation of the indirect stresses referred to.

A crack in the slab would not materially interfere with the operation of these indirect stresses in each segment of the multiple-way reinforced slab, while a crack in a beam normal to the direction of the steel would intercept any indirect tensions induced by the bond shear at the section checked, and prevent the accumulated resistance afforded by these indirect stresses from being effective in direct resistance to moment.

In treating the combination of the two materials, it has been customary to consider their combined action as determined by the elastic properties of each taken separately, that is, by considering the ratio of the modulus of elasticity of the concrete in compression and tension to the modulus of elasticity of the steel in tension and compression. In a homogeneous elastic slab, such as steel in the form of a plate, there would be taken into consideration in addition to the modulus of elasticity of the metal in tension and compression in one direction, the additional coefficient of modulus of lateral deformation known as Poisson's ratio. This ratio, or lateral effect, in a combination of steel and concrete which is sufficiently fine-grained to be regarded as acting like a homogeneous material, as is the case with reinforced concrete slabs, cannot be correctly considered as an elastic property of either the concrete or the metal, but on the contrary must be treated as a coefficient expressing the efficiency of the lateral action of the indirect stresses induced by the bond shear in the case of multiple way-reinforcement in the slab, which coefficient, for the reasons above explained, must be zero in the case of the beam type, with reinforcement in but one direction, or the case of the slab in which the reinforcement under strain runs in but one direction only. Although transverse reinforcement may be introduced in a beam, it can perform no useful function in reducing the stress on the carrying-rods, since the indirect stress induced by one series of rods under strain cannot converge to react upon another set of rods not under stress, but can react with that set of rods only when both are generating indirect lines of force arising from bond shear.

The indirect stress from bond shear to be depended upon must react upon other indirect stress and be held in equilibrium by these stresses generated by the steel. Otherwise, we are depending upon the direct tensile resistance of the concrete for bending, which is not considered permissible by those experienced in reinforced concrete design.

In the case of the beam with one-way reinforcement, there is no way for these stresses to react upon each other and be held in equilibrium by each other. The slab, however, furnishes a condition by which this desirable end is obtained.

The law governing the generation of bond shear indicates clearly that if this element of strength is to be

*Read before the Boston Society of Civil Engineers, on September 16, 1914.

utilized, wide-spreading reinforcement must be used. Otherwise, its efficiency is negligible. This law eliminates from consideration as an economic and successful flat slab, any arrangement of narrow belts or strips of reinforcement in a flat slab of uniform thickness which does not permit, by virtue of the arrangement, efficient operation of the forces outlined.

That the performance of a flat slab with multiple-way reinforcement is essentially different from the mechanical operation of one-way reinforcement in a beam is apparent if we consider that as a mechanism its operation is governed by the fundamental law known as the law of conservation of energy and its various corollaries. As a substantially elastic structure—and we are dealing with an elastic theory—the external work of the load must equal the internal work of deformation. It is true, of course, that the slab is not perfectly elastic because of shrinkage stresses, and because the concrete does not completely fulfil the conditions of a perfectly homogeneous elastic solid, but when the slab is thoroughly cured and of good concrete, its deportment for practical purposes may be treated on this basis.

The utility of the flat slab, as compared with beam construction, depends on lateral resistence, enabling the same resistance to be secured with a smaller thickness.

"The external work of the load equals the internal work of deformation, or the product of the force multiplied by the distance through which it moves is a measure of the internal work of resistance of the structure withstanding this force."

This statement (Clapeyron's Theorem, 1866) gives a basis for ascertaining the manner of the storage of potential energy in a reinforced concrete structure by which can be demonstrated the difference between the circumferential cantilever action, as in a Turner slab, and the lineal cantilever action, such as that of Hennebique, of the beam type. In considering this matter we will assume a Hennebique structure with the slab of the same thickness as the Turner floor-slab, and assume the same amount of cross-section of steel in the two cases.

Since the steel runs in multiple directions in the belts of Turner, having substantially uniform spacing, and since the material is strained circumferentially as well as radially, and in such a way that the circumferential and radial deformation must, from the geometry of the slab, be equal, it can be shown that the energy stored circumferentially about the cantilever head in the belts of rods is equal to that which is stored radially. Now if half our energy is stored circumferentially and half radially, it is evident that while the circumferential deformations are coincident with, and their magnitude dependent on, the radial deformations, it is the radial deformations or extensions along a meridian line which determines the vertical geometry of the slab. In other words, as half our energy is stored circumferentially, we have established a different method of storage of energy in the circumferential cantilever of Turner from the lineal cantilever of Hennebique. In the lineal cantilever no energy can be stored circumferentially, because the steel does not run in that direction; there is no reservoir, so to speak, in which to store it.

Suppose we assume that the same quantity of energy (symbolizing it by Q) is stored in each respective structure. Then, if the load be applied gradually, and we use W_1 to represent the load and H_1 the mean deflection of the lineal cantilever, we have

$$Q = \tfrac{1}{2} W_1 H_1 = \tfrac{1}{2} W_2 H_2,$$

W_2 and H_2 referring to the load and the deflection, respectively, of the circumferential cantilever. Now, if half the energy in the circumferential cantilever is stored circumferentially, and half radially, and that stored circumferentially produces no deflection, then $H_2 = \tfrac{1}{2} H_1$. That is, the mean deflection of the circumferential cantilever, represented by H_2, is only one-half the mean deflection of the lineal cantilever, represented by H_1. Likewise, Q being the same for each, $W_2 = 2 W_1$. But if we assume for purposes of closer comparison that the deflection be the same with each, instead of the quantity of energy stored being the same in each, then W_2 (the load of the circumferential cantilever) must equal $4 W_1$ or it will require *four* times the load to produce the same deflection with a circumferential cantilever, it being assumed, of course, that the same amount of steel is used that it will require with a linear cantilever in each, and that the same depth of slab is employed.

From this relation of the storage of energy, it is evident that a circumferential cantilever and suspended span slab of half the thickness will present the same rigidity as a continuous beam construction of double the depth, being a measure of the difference in deportment of beam action and slab action.

Bending Moments.—Regardless of the manner in which the load is carried to the support, it is an invariable or fundamental law for uniform loading that half the sum of the bending moments over the support, plus that at mid-span, equals a constant, equals $\frac{1}{8} WL$. This is true for a continuous beam, simple beam, a continuous slab, or a simple slab, or one fixed at one end and free at the other. From this relation we would have for a slab of indefinite extent, supported at points, as the magnitude of the moment at the support, $WL/12$, and the moment to be resisted at the centre, $WL/24$, and we are now in position to consider the modification due to the size of the capital. For the usual proportions this would reduce the moments just given to $WL/15$ and $WL/30$, respectively, for a single panel, but in the cantilever portion about the column these external moments or apparent moments, as Dr. Eddy treats them, are resisted in two ways—by true moments, in the steel radially, assisted by the bond shears coacting with each other and by true moments in the steel circumferentially, also assisted by the bond shear. Thus the radial moment in a line at the critical section about the cap to be resisted would be $WL/30$, which in the mushroom type is provided for by the combined radial rods and slab rods.

In the discussion thus far I have dealt generally with slabs of uniform thickness, and it is in order now to make a few remarks applicable to slabs not presenting this characteristic—that is, with a thickening up of the concrete at the column.

The general principle of rigidities must apply to this case. This principle may be stated as follows:

Where there are two or more paths by which the load may travel to the support, the load divides itself between the paths in proportion to their rigidities.

Increase of the rigidity of the cantilever portion throws the line of inflection outward, increasing the moment at the support and decreasing the moment at mid-span to the extent that the load is a balanced load and the column rigidity permits its action in this manner. As the writer views this modification of the slab, it is not an altogether desirable modification, for the reason that it involves increased bending at the column, a large increase in the apparent moment to be resisted over the support, decreased toughness and ability to resist unbalanced load.

I have pointed out the comparative stiffness and strength of a linear cantilever and a circumferential cantilever. It is next in order to show that in the suspended span-portion covered by crossed belts in a diagonal direction, the same relation holds true because of coaction between the two belts. In the direct belt there is no such action at the centre. The moment there, however, is reduced by the stress in the diagonal belt crossing and assisting it where there are four belts used. This assistance in the standard mushroom design with the proper width of belt, half the distance between columns will amount to practically six- to seven-tenths of the efficiency of the direct belt, so it is evident that, if the diagonal reinforcement is to be eliminated, the side-belts must be increased very largely or to nearly double the cross-sectional area required for the four-way system. This increase is brought about not only by reason of the relation just pointed out, but for the further reason that with a four-way arrangement, the resistance to circumferential stress by the steel is more complete than with a two-way arrangement.

In a short paper of this kind, a complete discussion of all phases of the problem would be beyond its scope. To point out the fundamental difference between beam action and slab action and to offer a simple explanation thereof is the object which has been aimed at. Of the large amount of work which has been constructed giving perfect satisfaction, there is required some explanation more consistent and rational than to say that the uncertain and unreliable tensile strength of the concrete has brought about such satisfactory result. For those who are inclined to consider that the direct tensile strength of the concrete can be credited with these results, such experiments as the writer has made, in which the slab when loaded carries the load by concrete tension very well at first but in the course of a week or ten days failed completely under the load, would carry conviction to those who would take the time to investigate. The difficulty, as the writer views it, of arriving at a scientific analysis of the slab, has been the confusion of the properties of a composite material with those of a homogeneous elastic body.

Reinforced concrete is not a homogeneous material, but consists of radically different elements, steel and concrete. The properties of these materials are radically different. They work together only by virtue of the bond shear or shrinkage grip between the two, and it is the property of this connecting link or lateral efficiency thereof which has been successfully treated as Poisson's ratio by Dr. Eddy in his mathematical analysis of the continuous flat plate.

The Poisson ratio with which Dr. Eddy deals, as I understand it, is not a property of either concrete or steel, and has absolutely no relation to any property of the two materials, but is nothing more nor less than the coefficient of the lateral efficiency of the indirect stresses induced by bond shear in their coaction with each other, which coaction occurs in such manner that the direct tensile strength of the concrete is not overtaxed, as would be the case where dependence is placed upon the energy stored by indirect stress in a one-way reinforced beam.

The difference in operation of one-way and two-way structures as machines for storing up of the energy developed by the load in its descent during deflection of the slab, is of interest. In a newly cast beam, the deflection for small loads is much less than we would figure by the ordinary theory. The energy stored by the indirect stresses arising from bond shear in tension, however, is not stored in a stable manner, because the concrete soon becomes overtaxed or cracks, and energy thus stored leaks away and is dissipated. Further energy is developed by the load in its future descent through increased deflection, which is stored in turn by the steel. This phenomenon is sometimes incorrectly described as the concrete relieving itself of the stress and throwing it upon the steel. As a matter of fact, no such interchange occurs. The energy stored in the concrete is lost and dissipated and new energy is developed by the load in its descent through increased deflection, which energy is stored up in the steel in a dependable manner. In the slab, on the contrary, where energy is stored by the coaction of one set of indirect stresses with another, the storage is a dependable one, for the reason that these stresses are not cumulative, since they are merely transferred through one set of rods to the other through the concrete as a conductor, and do not have any cumulative effect on the structure, as in one-way reinforcement.

Certainly a theory such as that of Dr. Eddy, which enables us to compute deflections accurately, and which gives the steel stress in accord with experiment, cannot be lightly dismissed, no matter with what disfavor Poisson's ratio, the basis of the computation, may be viewed.

In conclusion, I believe that a clean-cut understanding of the nature of the fundamental relations which I have pointed out may help clear up some of the mystery with which slab design has been obscured, and that a more complete discussion of the fundamental laws of mechanics applicable thereto will eliminate the many errors and inconsistencies in its design into which those have fallen who have given the subject insufficient study. One of the gravest mistakes and the most common one, has been that of using too high a percentage of steel, with the confident belief that this excess of steel would add materially to the strength of the structure. The performance of the scientifically designed flat slab under test, places the burden of proof upon the critic, to show wherein the method of design is in error, and it would seem that thus far all criticism of the successful flat slab had been based upon the gratuitous assumption that reinforced concrete is such an anomalous mechanism that its operation as a machine is totally independent of the law of conservation of energy and the principles of least work. Further, our critics would have us believe that its innumerable manifestations of strength should cause us to lose all confidence in the dependence usually placed on the law of gravitation as a proper basis for load tests.

Treating the scientific flat slab as a machine on the theory of work, we can readily check up Dr. Eddy's conclusions regarding the performance of the machine in respect to its deflection. We have shown that the circumferential cantilever is four times as stiff as the linear cantilever. Now the successful flat slab is a continuous construction and it would be four times as stiff as the continuous beam. The continuous beam, in turn, is five times as stiff as the simple beam. Hence, the continuous flat plate is twenty times as stiff as the simple flat plate, but in order to build a flat slab supported on columns we have to have support of, generally, two-tenths of the span in diameter. This reduction of the span to eight-tenths would render the slab forty times as stiff as a simple slab on knife-edge supports, were it not for the fact that the resisting section grows smaller in a continuous slab on posts as the post is approached. This difference reduces the relation from forty to approximately thirty times for the above ratio of metal to span.

It seems to the writer that the average structural engineer in the consideration of his structures, is more inclined to feel that he is dealing with a mere problem of static equilibrium than to consider the structure as a true machine in which all of the elements are put in motion by every change of load.

Looking at it in the true light of its operation as a machine, or mechanism, the theoretical error of disregarding the vital elements or parts of the machine in treating its operation becomes apparent. We would not consider it practical to expect satisfactory operation of an engine with the connecting-rod left off, and why should we consider any theory as applicable to the operation of the flat slab in which the connecting link between the concrete and the steel is left out of consideration? Such a theory must evidently be as unsatisfactory in application as the engine with the connecting-rod removed.

Failure to consider the continuous flat slab as a mechanism accounts for the strange misconception of its character by the great majority of the engineering profession. They look at the commercially successful flat slab as one which is merely flat on top and bottom. Certainly the writer was not a pioneer in flat-slab construction of this ancient and useless variety.

In the construction of the reservoir at Bridgewater, Mass., a slab flat on top and bottom was used, and strips of expanded metal marked "lintels" on the working drawing were stretched from column to column in two directions and expanded metal was spread in the bottom layer. The operation of this structure as a machine, however, would not be the mode of operation which I have outlined by the preceding theory of work. It is a different mechanism entirely. No useful circumferential action could occur in the upper zone about the column, while the difference in rigidity of the expanded metal in the two directions, longitudinally and transversely, would prevent any material circumferential resistance in the bottom between columns. The performance of other slabs, flat in form as machines, may be referred to here.

Mr. George Hill, of New York, in the "Architectural Record" of September, 1902, described the construction of a warehouse with columns 16 feet centres, slab 11 inches thick, designed to carry 400 pounds working load, or 52 tons per panel. Failure occurred under approximately half this supposedly safe load, and the floor is now supported on alternate brick piers and concrete posts 8 feet centres, or nine times as many points of support per panel, 16 feet square about the column, as originally designed.

A reservoir roof on a similar plan was attempted, with columns about 22 feet centres, slab between seven and eight inches thick. Instead of seven posts it now rests securely on somewhat over forty posts.

The performance of these structures as machines when the thickness of the slab is reduced so that stability must depend on the slab action was unsatisfactory, for the reason that the general laws necessary to secure satisfactory results were not complied with. The type of flat slab outlined in Taylor and Thompson's work would come somewhat under the same category as regards width of belt and proper distribution of the material over the columns, to secure the most effective reduction of the radial moment by circumferential action. Its glaring defects in this respect the writer has noted with surprise, but they seem not to be generally appreciated by the profession at large.

To undertake in a short paper the discussion of wall panels, column flexure, and other more intricate phases of the flat slab problem, while as yet the simplest and most elementary form of the problem, the interior panel, is not generally understood, would be, as the writer views it, a waste of effort. When there is more general agreement on the simplest form of the problem, then the more complex and interesting phases of the question are in order for discussion.

OPPORTUNITIES FOR CANADIAN PRODUCTION.

The following is a partial list of articles not manufactured in Canada, but all of which are imported. It has been compiled by the Department of Trade and Commerce, Ottawa, and may serve as suggestions to manufacturers of engineering machinery and equipment.

Asbestos pipe coverings; carbons, electric light; copper tubing, seamless; galvanized wire netting, 14 x 15 gauge; galvanized wire netting, any gauge, ¾ mesh and smaller; miniature electric incandescent lamps; pipe coverings of cork for cold storage insulation; rolled edge steel plates; safety fuses, not metallic; seamless steel boiler tubes; oil engines; sheet copper and seamless copper tubing; sheets, Bessemer; slag trucks; sockets, incandescent for street lamps, 1½-inch inside diameter and over; steam steering engines for equipment of ships; steel squares; telephone carbon protector blocks, carbon discs and glass lenses used in manufacture of telephone; tubing, seamless steel.

PROPOSED EXHIBIT OF U.S. STEEL CORPORATION AT PANAMA PACIFIC INTERNATIONAL EXPOSITION, 1915.

The announcement is made that the United States Steel Corporation and subsidiary companies propose to have a comprehensive exhibit of their operations at the Panama-Pacific Exposition in San Francisco in the year 1915. It will begin with the ore fields and carry on an educational picture of operations in ore mining, rail and water transportation, dock operations, coal, coke and pig-iron production, steel manufacturing in its various lines, and will also present in a displayed way the processes of manufacturing many of the subsidiary companies' products, also how their by-products are utilized, and the display of many of the uses in which their general products are employed, typifying the advancement in the uses of this country's resources. In addition to the material exhibits before mentioned the corporation intend to illustrate in a comprehensive manner, by moving pictures, their operations throughout all departments, showing the ramifications of the processes of the corporation's operations. It is proposed as well to set forth to the world the work which the United States Steel Corporation has done towards the social welfare of its employees and dependants. The corporation will also exhibit many forms of safety devices that have been conceived by its officials and employees, and in the installation of which large sums have been and are being expended. In this social welfare department will also be shown the methods employed by the corporation in the aid and care for the injured, and the welfare of employees' conditions at work and the benefits that are aimed to be afforded to employees at their work and in their surroundings.

MATERIALS AND SUPPLIES FOR SOUTH AMERICA.

United States Consuls reporting on the immediate necessities of Latin countries state that there will be opportunities for the sale of the following: Para, Brazil=cement and manufactured iron; Rio de Janiero, Brazil=cement, hardware, iron and steel wire; Montevideo, Uruguay=cement; Lima, Peru=cement, steel rails, tools, machinery, explosives; Bogota, Colombia=machinery, railroad supplies, engines, cars, rails, bridges.

GRAPHICAL METHOD FOR BEAM DEFLECTION

PRACTICAL SOLUTIONS TO COMPLICATED PROBLEMS IN THE DEFLECTION OF BEAMS, OBTAINED BY THE APPLICATION OF THE FOLLOWING GRAPHICAL METHOD.

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THE well-known formula for the deflection of a beam (due to the bending moment caused by the load), $\frac{d^2y}{dx^2} = \frac{M}{EI}$, where the values of x are horizontal and those of y vertical, M is the bending moment at any point, and E and I are the usual constants, affords a practical solution of such problems by a graphical method. Except for the simplest cases, the differential equation above is, at best, cumbersome to handle by the calculus, and, therefore, inefficient for practical purposes.

From this equation, $\frac{dy}{dx}$, which represents the slope of the elastic curve of the neutral axis at any point x, equals $\int \frac{Mdx}{EI}$, and y, which represents the vertical deflection at any point x, equals $\int\int \frac{Mdx^2}{EI}$. Also observe that $M = \int S\,dx$ and that $y = \int\int\int \frac{S\,dx^3}{EI}$, where S is the shearing force at x. If E and I are constant the following graphical method will be found valuable for complicated cases:—

Given a 6-in., 12.25-lb. I-beam, with the span and loading shown in Fig. 1, $E = 30{,}000{,}000$ lbs. per sq. in. $I = 21.8$ inches^4. Required the maximum deflection.

The method is as follows: The shearing force curve was first plotted as shown in Fig. 1, and from this the bending moment curve was obtained as follows: Vertical strips 1 foot wide to scale were taken and the middle ordinate of each strip was laid off on a vertical line at the right-hand end of the beam. The point P was chosen as a convenient pole, and the curve constructed in the same manner as an equilibrium polygon. Note that the edges of the strips were connected by the strings and not the middle ordinates.

Again, taking the middle ordinates of the bending moment curve, in the same way a new curve, the slope curve, is constructed. The ordinates to this curve give the slope at any point. Here, it is to be noted that to draw these curves in their proper position they must be made to conform to certain known conditions. The value of the bending moment is zero at the end of the beam; therefore, its curve must pass through zero at that point. The slope of the deflection curve is zero at the middle of the beam; therefore the slope curve must pass through zero at that point; and it has been so drawn. Finally, from the slope curve the deflection curve has been drawn in the same way, passing through zero at the ends of the beam, because the deflection here is known to be zero from the conditions of the problem.

Care must be taken with the scales, but there is no difficulty involved if they are put down as follows:—

First Scale: Horizontal, 1 in. = 2 ft.; vertical, 1 in. = 500 lbs.; pole distance = 6 ft.

For the Second Scale multiply the pole distance into the vertical scale of the First Scale.

Vertical, 1 in. = 3,000 foot-pounds.
Pole distance = 6 feet.

In the Third Scale the vertical is obtained in the same way.

Vertical, 1 in. = 18,000 pound-feet^2.
Pole distance = 6 feet.

For the Fourth Scale, the vertical scale,
1 in. = 108,000 pound-feet^3.

The deflection at any point is now obtained by scaling the vertical ordinate at the point to the deflection curve in inches (use a scale graduated to 100ths of an inch). Multiply this by 108,000 ft.-pds. and by 12 to obtain the deflection in inches. The product EI in the denominator must also be inserted.

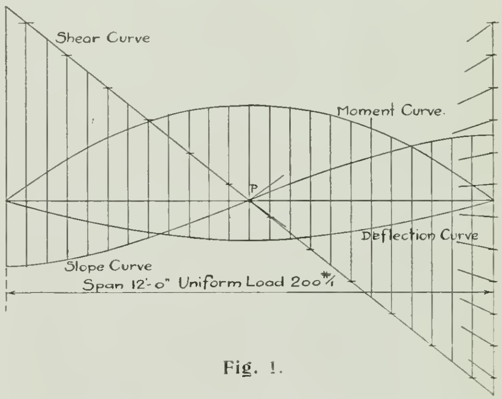

Fig. 1.

The results for this case are as follows:—

Scaled maximum ordinate on the deflection curve at centre = .50 inches.

$$\text{Deflection, } \frac{108{,}000. \times .50 \times 12^3}{30{,}000{,}000. \times 21.8} = .1427 \text{ inches.}$$

From the formula—

$$\text{Deflection, } \frac{5 \times 200. \times 12^4 \times 12^3}{384. \times 30{,}000{,}000. \times 21.8} = .1429 \text{ inches.}$$

Such extreme accuracy as this is due more to good fortune than to anything else, but it goes to show that the results so obtained are sufficiently accurate for practical purposes.

Let it be required to find the deflection of any point, "a," of the beam, with its loading, shown in Fig. 2. Fig. 3 shows the shearing force, bending moment, slope and deflection curves. The slope curve is not in its cor-

rect position, due to the fact that the constants of integration are determined by conditions imposed on the deflection curve, and, therefore, are not determined until this curve is drawn. These conditions are that the deflection curve shall pass through zero at each of the reactions. The slope curve could easily be shifted to its

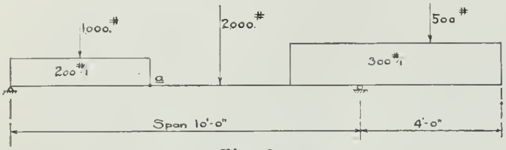

Fig. 2.

proper place, but that is hardly necessary, since the deflection curve is all that is desired in this instance. The deflection curve was made to pass through the required points by one of the several well-known methods for passing a polygon through two points. The choice of the last pole for this curve, therefore, was not wholly arbitrary and had to be scaled.

The scales work out as follows:—

First Scale: Horizontal, 1 in. = 2 ft.; vertical, 1 in. = 500 lbs.; pole distance, 4 ft.

Second Scale: Vertical, 1 in. = 2,000 foot-pounds. Pole distance, 4 feet.

Third Scale: Vertical, 1 in. = 8,000 pound-feet^2. Pole distance, 2.88 feet.

Fourth Scale: Vertical, 1 in. = 23,040 pound-feet^3.

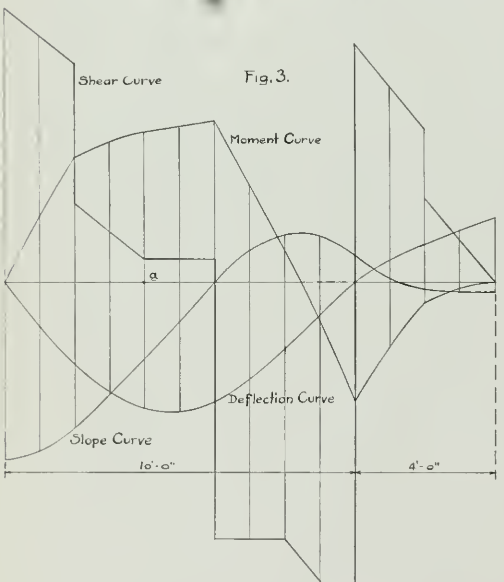

Fig. 3.

The scaled distance in inches to the deflection curve at "a" = 1.80 inches.

$$\text{Deflection, } \frac{23{,}040. \times 1.80 \times 12^3}{30{,}000{,}000. \times 21.8} = .1095 \text{ inches.}$$

Suppose that the beam shown in Fig. 2 is continuous over three supports and that the third support is at "a." To determine the reaction there it is required to find the single force which will cause a deflection at "a" of .1095 inches in the same beam. Substituting the numerical values in the formula for the deflection of a point on a beam with a single load and solving for the unknown load, it becomes in this case equal to 2,160 pounds. If this force of 2,160 pounds were to act upwards at point "a" in Fig. 2 it would deflect that point back to zero and the deflection curve for the beam over three supports would pass through zero.

In order to plot the deflection curve, plot first the deflection curve for the upward reaction in the same manner as demonstrated above. Observe that the same pole distances and the same scales should be used, so that the scale of this deflection curve will be the same as the previous one above. The final curve may be plotted by taking the algebraic sum of the ordinates of each curve at each point.

A fourth reaction might now be considered and treated in the same manner, but the solution would be much more complicated and laborious. It would require the drawing of a deflection curve for the beam over three supports and loaded with this fourth reaction. No new methods would be involved, however, and the work has, therefore, not been extended.

Besides being valuable as a practical application, those who are teaching the subject of the deflection of beams will find the above method very instructive. It shows graphically to the student the relations of the shearing force, bending moment, slope and deflection curves to one another.

TORONTO ELECTRIC DISTRIBUTION SYSTEM.

A quantity of underground work in connection with the Hydro-Electric distribution system has recently been under construction in Toronto. This consists of building a 15-duct run on the south side of King Street from John Street to Jarvis Street. Single 3-in clay ducts are laid three wide and five high, the top layer being square bore distributer duct. Several difficult channels have had to be made under car tracks—namely at York Street, Bay Street, Yonge Street, and Church Street. A single fibre duct of 3-in. diameter is used to connect run to all service boxes in the old run in the sidewalk. The ducts are encased in three inches of concrete and are laid with a minimum cover of 30 ins. from top of pavement.

In addition to the above work six large concrete transformer pits are being built. The dimensions of these pits are 9 ft. x 20 ft. deep, inside measurement. The pits will have 13-in. concrete walls and will be provided with special ventilation chambers. These pits are of sufficient size to take care of additional load in future years.

RAILWAY EXTENSION IN CHILE.

The Northern Longitudinal Railway of Chile is now in full operation, the work being entirely completed connecting Pisagua in the north of Chile with Valparaiso, Santiago, and Puerto Montt, well to the south of the country, a distance of about 1,960 miles. The new portion from Iquique to Calera, a distance of about 750 miles, has been constructed within the past three years; has cost about $40,000,000; and is to be operated for 50 years by the Chilean Northern Railway Company, Calera, Chile, an operating company organized by the Howard syndicate, which supplied the money under a guaranty from the Chilean Government. The gauge of this line is 3.28 feet, while the gauge of the old portion of the Longitudinal Railway is 5 feet 6 inches. A full description of this railway appeared in *The Canadian Engineer* for March 19th, 1914.

C. S. Cameron, secretary and treasurer of the Sydney Steel plant, has gone to England to investigate the opportunities for trade in the British market.

REINFORCED CONCRETE DOCK FAILURES.

THE subject of reinforced concrete dock construction has been given considerable study in these columns. In our issues of August 27th and October 1st, the extent of this form of dock construction was outlined as regards practice in England and America respectively. In reviewing what has been done thus with reinforced concrete, it is necessary to state that it has not withstood in every instance subjection to the action of sea water. For the results of an extensive investigation into the effect of alkali and sea water upon concrete structures, the reader is referred to an article on the subject in *The Canadian Engineer*, July 31, 1913, page 233. The following, which is a continuation of the subject of reinforced concrete dock construction, outlines the failures that have occurred, and it is to be noted that they are due chiefly to the above cause.

In discussing reinforced concrete docks, the fact that there have been failures among them must not be overlooked. In Massachusetts waters, north of Cape Cod, a number of serious cases of deterioration of concrete have been caused by the disintegrating effects of sea water, wave action, and frost, especially in Boston Harbor, where nearly all the concrete structures standing in sea water have been affected badly between high and low tide, the most notable instance of which is the concrete pier at the Charleston Navy Yard. Although that part of the pier which is constantly submerged has given but little trouble, the part exposed alternately to the sea and air has been seriously affected, many large pieces having broken completely away, making it self-evident that some other agent than the chemical action between cement and sea water was at work.

As is well known, winter temperatures on the whole eastern front of the New England Coast run far below zero. In Boston Harbor 12° below zero is not uncommon. In the same way that hard earth and porous rocks are broken up by frost action, permeable concrete in freezing water will gradually be destroyed between wind and sea, as the water which gets into the concrete simply exercises its natural expanding function in freezing, which *a priori* is detrimental to the concrete structure. It is generally admitted that the exterior concrete in these Boston structures, especially in the Navy Yard pier, has failed almost entirely from the effect of the alternate freezing and thawing with each tide during the winter, due to permeable concrete.

A number of failures similar to that already cited have occurred in Boston, the disintegration taking place in all cases between low and high tides. In the case of the Dover Street draw-bridge pier, built in 1894, the disintegration had extended 1.4 ft. into the pier at the end of 17 years, the greatest damage being just below high-tide level. The pier was built of 1 : 2 : 5 concrete, with a 1-in. plastered mortar facing. English Portland cement was used throughout. Whether the 1-in. facing mortar was expected to act as a waterproof shield to the interior concrete is not apparent. Evidently, it did not act thus, as might have been expected.

As all the concrete in these disastrous cases seems to have been placed in the wet, that is, the sea water was allowed to come in contact with the concrete before it had become thoroughly cured and hardened, such results are not to be wondered at, for one of the axioms of a successful use of concrete in sea water is that it must be kept from contact with sea water for such a period of time as to enable it to become thoroughly hardened, especially that part between tides in freezing climates.

In several cases in Boston Harbor where the concrete was placed inside of a coffer-dam, or used in the form of pre-moulded, driven, concrete piles, the concrete does not seem to have been affected as in the other cases cited. These successful cases go a long way toward substantiating the truism that concrete, to be used successfully in sea water, especially in freezing water, must be made impermeable in the process of making, with full consideration given to the brand of cement used, the mixture, the sand, and stone (or gravel), the skilled labor of placing, as well as keeping it from contact with sea water until it has set and hardened sufficiently. It is very apparent, from a study of the method used in placing the concrete in the disintegrated structures in Boston Harbor, that that method was far from possessing the essential features necessary for a successful solution of the problem, viewed in the light of present-day knowledge.

In comparison with these Boston failures, it is fitting to state that at Dundee, Scotland, where the climatic conditions are said to be worse than at Boston, and where there is a rise and fall of the tide of about 12 ft., the combined action of the sea, waves, and frost has had no ill effect on the concrete docks in that harbor, the concrete piles of which were allowed to harden for 30 days before being put in place.

Another noted case of the destruction of concrete by frost and sea action is the large concrete sea wall along the water front of Lynn, Mass.—a massive concrete sea wall exposed to the pounding of the winter storms and seas. The steps to the beach in the front of this wall were destroyed to such an extent as to be hardly recognizable as steps. It might be of interest to state that this wall and some of the damaged structures in Boston harbor have apparently been repaired effectively by the cemen gun process.

In reviewing these failures in Boston and vicinity, it is well to consider the results obtained in using concrete in another port subject to freezing and ice conditions, viz., New York Harbor. In addition to freezing conditions, New York Harbor has to contend with a strong tidal effect, which results in large solid ice floes and fields of broken ice moving back and forth with a tide of considerable velocity, ice floes of such size coming down the Hudson as at times practically to compel abandonment of all transfer traffic in that river. This is an effect from which Boston docks are perhaps free, as no large rivers flow into that harbor, the Charles being kept under control by the so-called Charles River Dam.

In discussing this additional handicap and destructive force at work on New York City's 8¼ miles of concrete sea walls, some of which have been in existence for 41 years, Charles W. Staniford, M. Am. Soc. C.E., Chief Engineer of the New York Department of Docks and Ferries, states:

"Up to the present time (August, 1911), no disintegration has been discovered that can be attributed to the existence of the structure in salt water. The concrete itself is in an admirable state of preservation, absolutely hard, and is undergoing no regular process of disintegration." * * * "this sea-wall which has been under construction * * * for 41 years, is at the present time an excellent piece of work and is subject to the same climatic conditions as all cities on the Northern Atlantic Coast with the attending ice, cold and rain characteristic of this latitude."

In many instances, parts of this wall above low water are faced with granite blocks. This is a noted example of what can be expected in the way of using mass concrete in sea water if properly made, though perhaps some repair work has been necessary in order to maintain the excellent condition of the wall.

In some of the earlier sections of this wall the concrete was placed "*en-mass*-in-site," but, since 1876, most of the wall has been built by the concrete block method. Only under specially favorable conditions is it possible to place concrete successfully *in situ* under (sea) water, as it becomes disintegrated "through the chemical action of the sulphate of magnesia on fresh concrete or through the resulting porosity of concrete due to the impossibility of tamping under water";* the viscosity and weight of the mass not being sufficient to produce such a dense material as obtained in block work.

To discuss an opposite case in New York Harbor, viz., Dry Dock No. 2, New York Navy Yard, originally built of timber in 1890, the history of which it is not necessary to relate here: In 1900 this dock was rebuilt, concrete being used very extensively. During 1913 a large sum was expended in repairing and replacing the concrete altars and floors. As it has been stated that the difficulties of using concrete in sea water have been so great at this yard as to indicate that this is not a permanent material for use in sea water structures, it would be of deep interest to learn the facts as to the chemical composition of the cement used, of the sand and stone, as to the mixture thereof, and the precautions taken in mixing and placing; also as to whether the dock is kept flooded when not in use, especially during the winter. If, as has been stated, the concrete "has deteriorated and disintegrated to such an extent that it was possible to use a pick and shovel in removing it," it is apparent that it was lacking in one or more of the essential features that are deemed absolutely necessary for a successful use of concrete in sea water structures.

Whether any of the concrete pile docks on the Great Lakes have shown any signs of deterioration due to frost action, the writer does not know, but trusts that some facts covering this question will be brought out in the discussion. As the water level is practically the same all through the winter, only a very short length of the pile would be affected, and not some 10 ft., as in Boston Harbor.

One of the first concrete docks built in San Francisco is said to have failed in part due to poor construction. The early method of building the concrete columns of San Francisco concrete docks was to use a wooden cylinder, strongly built, as a column form, into which, it has been stated, the concrete was poured, apparently without any attempt to pump out the cylinder. As long as the wooden cylindrical forms remained in place around the supposedly concrete column, the dock was pronounced a success. When the teredo had finally destroyed the forms, the columns began to collapse and the dock became a pronounced failure, because, in pouring the concrete, the heavier material—the stone or gravel—settled first, then the sand, and finally the cement. The result was that throughout the length of the concrete columns there were alternate layers of uncemented stone and sand, with the cement in between the sand of one batch and the stone of the following one. Concrete can be and is successfully dropped through a height of 50 ft.—and even up to 100 ft. in one noted case in Arizona—but, if the receptacle into which it is dropped is full of water, disaster alone awaits the unfortunate engineer.

In another of the San Francisco docks, where wooden piles supported the concrete columns, the concrete was not carried down below the mud line a sufficient distance to prevent the teredo from destroying the piles below the concrete.

The question has been raised: Has any deterioration taken place in concrete structures standing in sea water in the harbors of the Southern States, where frost action is unknown? The most prominent concrete structure thus situated is the famous viaduct across the Florida Keys, built of Alsen cement, imported from Germany. It is possible that some of the members of this society are in a position to give complete information regarding the action of salt water and the waves of the Gulf on this structure.

In order to guard against the disintegration (irrespective of its cause) of mass concrete placed *in situ* above low water, or to repair any damage that has been done, besides the cement gun process, various methods have been used, all based on the fundamental principle of using an impermeable material for the facing of the structure. Below low water, properly made block work has given most satisfactory results. Carefully made, fully cured pre-moulded concrete piles seem to resist the action of the sea and frost successfully. In Holland, hard, impermeable brick have been used to prevent any further damage to one of the breakwaters above low water. In England, the upper parts of massive breakwaters are mostly faced with granite or some other hard suitable stone. In Nova Scotia, both brick and pre-moulded blocks of concrete of small size were placed on the face of a concrete sea wall after the disintegrated concrete had been removed. A still more recent device is the use of hollow, vitrified, salt-glazed tile blocks filled with concrete after being put in place. Experiments thus far seem to have proved that:

"Vitrified salt-glazed tile is impervious to any deteriorating action of sea water, and has an effective structure against the battering of ice; it is so dense as to preclude the possibility of any water entering and freezing in it to the consequent destruction of the tile."

Though oiled concrete is being used as a waterproof material in certain cases, it is possible that the refuse, oil, gases, etc., discharged from certain classes of buildings, etc., might have a destructive effect on the concrete foundation piles or other parts of the building, especially in sea water heavily charged with sewage. It is a well-known fact that concrete sewers will not perform their duty properly for any length of time unless they have a brick lining invert, over which flows the heavy sludge. In time of flood the surface water is so great as to dilute the sewage and prevent injurious effects. The writer would be pleased to hear opinions on this point, as it is possible that a destructive effect might have been caused by sewage in connection with one of the most seriously affected cases in Boston.

Although poor results seem to have attended quite a number of the reinforced concrete structures standing in sea water in America, the opposite appears to have been true in foreign countries. Still, a few failures are on record as having occurred in England and Germany, due mostly to permeable concrete.

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*This subject is discussed further by the writer in an article entitled "Chemistry of Salt Water Cement," Metallurgical and Chemical Engineering, January and February, 1914.

GERMANY ELIMINATED FROM THE IRON AND STEEL TRADE.

THE German export business in iron and steel and manufactures thereof is rapidly being distributed among other nations, chiefly Great Britain and the United States. How extensive this transformation is, and to what degree these two countries may be relied upon to adequately supply the demand occasioned by the suspension of German exports, appear from the following comparative figures. It is to be noted that the figures pertaining to Germany and the United States include not only iron and steel, but also manufactures thereof, such as machinery and hardware, whereas the British figures comprise iron and steel alone:

Year.	Germany. (in marks)	United States. $	Great Britain. Tons.	Great Britain. £
1912 ..	1,275,053,000	259,709,399	4,814,005	49,800,000
1911 ..	1,100,133,000	230,725,351	4,515,905	44,800,000
1910 ..	923,705,000	179,133,186	4,588,009	42,976,671
1909 ..	780,760,000	144,951,357	4,210,799	38,192,142
1908 ..	772,673,000	183,982,182	4,096,521	37,406,028
1907 ..	852,650,000	181,530,871	5,152,227	46,563,386
1906 ..	715,043,000	160,984,985	4,682,200	39,840,595
1905 ..	639,934,000	134,728,363	3,721,382	31,826,438
1904 ..	582,322,000	111,948,586	3,262,842	28,066,671
1903 ..	634,361,000	96,642,467	3,564,601	30,399,261
1902 ..	603,375,000	98,552,562	3,579,104	28,877,337
1901 ..	517,259,000	117,319,320	2,897,719	25,008,757
1900 ..	479,609,000	121,913,548	3,540,689	31,623,353
1896 ..	337,540,000	41,160,877	3,550,398	23,462,793

Because of the difference in classification methods, comparisons drawn from these figures are somewhat unfair to Great Britain in that British exports of iron and steel and manufactures thereof increase more rapidly than her exports of iron and steel alone. However, it is still true that Germany has been increasing her iron and steel export trade more rapidly than Great Britain, but less rapidly than the United States.

Since the panic of 1907 German exports have increased in value 65.01%, while those of the United States have grown 110.14%. British exports of steel and iron, in tons, meantime increased 17.51%. But if the British figures included manufactures of iron and steel, they would show a gain of about 30% or 35%. From 1907 to 1912 the gain in British exports of iron and steel alone, as measured in pounds sterling, was 33.15%, as compared with 64.81% in German exports likewise classified.

Great Britain, Germany and the United States are the world's great steel makers; and with Germany eliminated for an indefinite period there should be a large opportunity for her two great competitors. The value of her exports in 1912, when reduced to our money, was $303,462,600; and much of this foreign trade was in steel products and, therefore, competitive merchandise. The largest single item of steel and iron themselves was malleable iron bars, and next to this came steel rails, then rough bars and ingots, iron wire, plates and sheets, and angle iron. The other countries produce large quantities of all of these; and what is more to the point is that the plant capacity of their steel mills has been so vastly increased during the past few years that if allowed to do so they could probably supply all of Germany's foreign customers in these products, as well as their own.

Water-Bound Macadam is being used in the Panama-Pacific Exposition for most of the streets and driveways, the total wearing surface of which is about 144,000 sq. yds.

SOME TUNNELING COSTS.

(Continued from last week.)

Stilwell Tunnel.

Location: Telluride, Colo.

Purpose: Mine drainage and development.

Cross-section: Square, with ditch at side.

Size: 7 by 7 feet.

Length: 2,950 feet.

Character of rock penetrated: Conglomerate and andesite.

Type of power: Purchased electric current.

Ventilator: Fan.

Size of ventilating pipe: 10 inches.

Drills: Started with electric drills, finished with pneumatic piston drills, using 2 in the heading.

Mounting of drills: Vertical columns.

Number of holes per round: 16.

Average depth of round: 6 to 6½ feet.

Number of drillers and helpers per shift: 2 drillers and 2 helpers.

Number of drill shifts per day: 1.

Explosive: 40 per cent. gelatine dynamite.

Number of muckers per shift: 3.

Number of mucking shifts per day: 1.

Type of haulage: Horses.

Wages: Drillers $4.50, helpers $4, muckers and trammers $3.50, blacksmith $4.50.

Maximum progress in any calendar month: 170 feet, August, 1904.

Average monthly progress: 150 feet (last 10 months).

Cost of Driving.

	Feet.	Cost per foot of tunnel.
1901	12	$23.88
1901-2	490	22.98
1902-3	377	27.94
1903-4	702	21.69
1904-5	1,077	21.19
1905	292	30.37
Average for	2,950	$23.38

These costs include all labor, supplies, repairs, powder, fuse, caps, candles, tools, lubricants, and general expenses, and the total value of the electric-drill plant with which the tunnel was started, and the total value of the air-drill plant which succeeded it, together with tunnel buildings, pipe, rails, and the ventilator, with no credit for salvage on any of this permanent equipment.

The fiscal year dated from September 30.

The tunnel was driven in 1901-3 with electric drills, and the high cost for:

1905 .... 292 $30.37

Strawberry Tunnel.

Location: Utah and Wasatch Counties, Utah.

Purpose: Irrigation and reclamation.

Cross-section: Straight bottom and walls, with arched roof.

Size: 8 feet wide by 9½ feet high.

Length: 19,100 feet.

Character of rock penetrated: Limestone with interbedded sandstone, and sandstone with interbedded shale.

Type of power: Electric power generated in a hydraulic plant operated in connection with the tunnel. Dis-

tance of transmission from west portal to power house approximately 23 miles.

Ventilator: Pressure blower.

Size of ventilating pipe: 14 inches.

Drills: Piston pneumatic, usually 2 in the heading.

Mounting of drills: Vertical columns.

Number of holes per round: 16 to 18.

Number of drillers and helpers per shift: 2 drillers and 2 helpers.

Number of drill shifts per day: 3.

Explosive: 40 per cent. gelatine dynamite.

Number of muckers per shift: 6.

Number of mucking shifts per day: 3.

Type of haulage: Electric after first 2,000 feet.

Wages: Drillers $3.50, helpers $3.25, muckers $2.75, motormen $3.25, brakemen $2.75, blacksmiths $4, helpers $2.75.

Maximum progress in any calendar month: 500 feet, November, 1910.

Average monthly progress: 320 feet per heading.

Cost of Driving.

	Feet.	Cost per foot of tunnel.
West heading:		
Previous to 1909	1,613	$60.05
During 1909	3,892	33.58
During 1910	5,021	30.56
During 1911	3,491	41.52
January to July, 1912	2,382	36.79
East heading:		
October, 1911, to July, 1912	2,682	33.04
Average for	19,081	$36.78

Detailed Cost of Driving the West Heading for the Year 1909, 3,892 Feet.

	Cost per foot of tunnel.	
Labor:		
Engineering	$0.49	
Superintendence	.73	
Shift bosses	1.22	
Timekeepers	.36	
Drillmen and helpers	3.15	
Miners (for handwork, trimming, etc.)	.23	
Muckers	2.96	
Track and dumpmen	.74	
Mule drivers	.39	
Motormen and brakemen	.44	
Electricians and blower men	.07	
Disabled employees	.19	
Timbermen	.22	
Miscellaneous	.40	
		$11.59
Materials:		
Powder, fuse, caps, etc.	3.08	
Lumber	.29	
Oils, candles, etc.	.22	
Ventilating pipe	.64	
Track, including ties	.68	
Pressure air pipe	.40	
Drill repair parts (including hose)	.18	
Miscellaneous	.19	
		5.68
Repairs:		
Machine-shop expense (including labor and supplies)	.93	
Blacksmith-shop expense (including labor and supplies)	1.22	
		2.15
Power (all purposes)		7.65
Depreciation:		
Haulage equipment	.09	
General equipment	1.00	
		1.09
General expense	3.96	
Camp expense	1.21	
Corral expense	.25	
		5.42
Total		$33.58

"General expense" includes a proportionate charge for the expenses of the Provo office, such as salaries, stationery, telephone, and supplies; also a proportionate charge for the expenses of the Washington, the Chicago, and the supervising engineer's offices. The Provo office covers approximately 68 per cent. of this charge, the Washington office 23 per cent., the Chicago office 2 per cent., and the supervising engineer's office 7 per cent.

Gunnison Tunnel.

Location: Montrose, Colo.

Purpose: Irrigation and reclamation.

Shape of cross-section: Horseshoe.

Size: 10 feet wide at the bottom, 10 feet 6 inches wide at the spring line, 10 feet high at the spring line, 12 feet 4 inches high at the centre of the arch.

Length: 30,645 feet.

Character of rock penetrated: Chiefly metamorphosed granite with some water-bearing clay and gravel, some hard black shale, and a zone of faulted and broken rock.

Type of power: Steam.

Ventilator: Pressure blower.

Size of ventilating pipe: 17 inches.

Drills: At first, pneumatic hammer, 4 drills in the heading; afterwards, pneumatic piston, 4 drills in the heading.

Mounting of drills: Horizontal bar for the hammer drills, vertical columns for the piston drills.

Number of holes per round: 20 to 24 in the heading (approximately one-half of the tunnel).

Average depth of round: 6 to 7 feet.

Number of drillers and helpers per shift: 4 drillers and 2 helpers.

Number of drill shifts per day: 3.

Explosive: 60 per cent. gelatine dynamite, with some 40 per cent.

Number of muckers per shift: 5 to 8.

Number of mucking shifts per day: 3.

Type of haulage: Electric.

Wages: Drillers $3.50 and $4, helpers $3 and $3.50, muckers $2.50 and $3, blacksmiths $3.50 and $4, motormen $3, brakemen $2.50 and $3, power engineers $4.

Maximum progress in any calendar month: 449 feet.

Average monthly progress: 250 feet, approximately.

Cost of Driving.

	Cost per foot of tunnel.
10,019 feet driven by undercut heading and subsequent enlargement	$87.23
20,626 feet driven by top heading and bench	62.18
Average cost of excavation of entire tunnel	70.66

These costs include all labor, all materials, all repairs, all power, depreciation figured as 100 per cent. on all equipment, with a proportionate charge for general (supervisory) and miscellaneous expenses of the entire reclamation project.

LARAMIE-POUDRE TUNNEL.

Location: Home, Colo.

Purpose: Irrigation.

Cross-section: Rectangular.

Size: 9½ feet wide by 7½ feet high.

Length: 11,306 feet.

Character of rock penetrated: Close-grained red and gray granite.

Type of power: Hydraulic at the east end, electric at the west.

Ventilator: Pressure blower.

Size of ventilating pipe: 14 and 15 inches.

Drills: 3 pneumatic hammer.

Mounting of drills: Horizontal bar.

Number of holes per round: 21 to 23.

Average depth of round: 10 feet at first, 7 to 8 feet later.

Number of drillers and helpers per shift: 3 drillers, 2 helpers.

Number of drill shifts per day: 3.

Explosive: 60 per cent. gelatine dynamite, with some 100 per cent. in the cut holes.

Number of muckers per shift: 6.

Number of mucking shifts per day: 3.

Type of haulage: Mules.

Wages: Drillers $4.50, helpers $4, muckers $3.50, blacksmiths $5, drivers $4.50, dumpmen $3.50.

Maximum progress in any calendar month: 653 feet, March, 1911.

Average monthly progress: 509 feet (for the 16 months when complete plant operated).

Special feature: Inaccessibility; the tunnel was located about 60 miles from the nearest railroad siding, and the roads were mountainous and very steep in places.

Cost of Driving 11,306 Feet.

	Cost per foot of tunnel.
Superintendents and foremen	$1.50
Drilling	4.47
Mucking and loading	4.92
Tramming and dumping	4.63
Track and pipe	.47
Power house	.35
Blacksmithing	.84
Repairs	.47
Bonus to workmen	1.75
Maintenance of camps, buildings and fuel	.62
Machinery repairs	.12
Air drills and parts	1.33
Picks, shovels and steel	.84
Explosives	4.50
Lamps and candles	.42
Oil and waste	.38
Blacksmith supplies	.53
Liability insurance	.81
Office supplies, telephone and bookkeeping	.86
	$29.81
Permanent equipment (less approximately 10 per cent. salvage)	9.73
	$39.54

The permanent equipment included power plant, camp buildings and furnishings, pipes, rails, etc.

PRESERVATIVE TREATMENT OF POLES FOR LINE WIRES.

THE normal yearly production of poles in the United States is about 2,750,000, and to-day there are, approximately, over 50,000,000 poles supporting wires, either telephone, telegraph, light, or power. It is only of recent years that the pole user could be induced to take the precaution of preserving his timber.

In the last few years, prompted by their increased price, there is hardly a pole set without the owner's having some idea of preserving it. He begins to compare what he or his predecessor formerly paid for a pole with the present price, hence he begins to figure how to stop the expense of replacing rotten poles.

Since the records obtained in the past years show what ingredients remain in treated timbers the greatest period of time, it is natural to conclude that a good preservative should contain as great an amount of these ingredients as it is possible to obtain. The impregnating process, while one of the oldest methods known, is yet in its infancy. The records referred to, however, are based on timbers which had been treated with a tar oil under pressure. This method, if properly used, is frequently so expensive that the additional cost makes its use prohibitory.

It is the high boiling oils of coal tar which preserve timber, because that is what was obtained by subjecting the preserved timbers to dry distillation. The records do not show whether or not these high boiling oils originally contained any neutral, such as paraffin or similar oils, which have not as yet been proven germicidal.

The average tar oil obtainable, which is forced into timber under pressure, contains from 15 to 35 per cent. oil distilling above 300 degrees centigrade. Hence, if an oil that contained 35 per cent. distilling above 300 degrees centigrade, at most, which had been injected into the timber showed such excellent results, it is reasonable to suppose that a lesser amount of oil containing proportionally a greater per cent. of distillate above 300 degrees centigrade will bring good results when properly applied.

It is important for the one who supposes petroleum to be a preservative to exercise much care in the selection of the petroleum because it may prove an unwise form of economy, as it has repeatedly.

In 1900 the C-A-Wood-Preserver Company began directing attention to the value of high boiling tar oils as against the offered "secret" or "patented" process in connection with preservatives. Since scientific investigations by the government and others have substantiated these theories and arguments, some are attempting to use preservatives which are the high boiling portions of crude petroleum. These mislead the chemist unless he make the sulphonation test. The company mentioned, in 1886, sold one of the first barrels of coal tar distillate that came to America. This product, which was intended for the superficial method, distilled only 75 per cent. above 300 degrees centigrade. Eleven years afterward this was increased to 85 per cent. and during the summer of 1909 to 92 per cent. This was the highest mark reached so far and it required special machinery to produce it.

It is practically impossible to produce a successful oil distilling more than 92 per cent. above 300 degrees centigrade according to the United States Forest Service method of analysis, as it would solidify at normal temperature if it were free from petroleum residues or similar oils. Some tars will distill much more than 92 per cent.

above 300 degrees centigrade, but they are not free from the paraffin oils which have a high boiling point though they are nongermicidal.

While it has been less than a year since a strictly coal tar distillate containing as much as 92 per cent. liquid residue (oil) above 300 degrees centigrade (United States Forest Service method) has been manufactured and put on the market, it may be interesting to note a few records and illustrations of the methods of application and results derived from the use of that heretofore produced, or from the oil distilling 85 per cent. above 300 degrees centigrade.

After determining the quality of preservative, the pole user is interested in the method of application. The brush method is the simplest and most universally used. Next is the pouring system, which is done in two ways. One consists of a portable tank, while the other is stationary, the poles being conveyed to the treating tank.

Poles which are already erected and which have begun to show decay can be saved by a very simple method. By digging away the earth to a depth of about two feet around the pole, applying two coats of a good preservative with a brush and then replacing the earth, the pole is saved. Rot is caused by a germ and the preservative being a germicide or antiseptic kills those present when applied to the decaying parts and its presence in the wood prevents future decay as well. The manager of the Memphis (Tenn.) Telephone Company, in 1904, made this experiment on cypress poles and he reports them in perfect condition to-day with every evidence of lasting many years longer. The Austin (Texas) Electric Railway Company has likewise found this a most successful experiment on cedar poles.

Cross arms can be treated by the brush method, however, the complete dipping or immersion is the more favorable. The cost of treating a pole depends upon its size, character, condition, price of the preservative and the amount used—whether it be treated at the ground line only or the entire butt end. There is a variation from four cents to perhaps a dollar per pole and each user of poles knows best what he can afford to pay for the protection of his timber.

Last, but not the least important, it should be noted that under no circumstances should unseasoned or green timber be treated, regardless of the preservative used; it must be at least partly seasoned to allow penetration.—*Municipal Engineering.*

MILEAGE ON THE N.T.R.

The accompanying chart, denoting the mileage between principal points on the Eastern Division, (Moncton to Winnipeg), of the National Transcontinental Railway is self-explanatory. Special attention is called to it, however, in connection with the concise review of the construction of the N.T.R. appearing in *The Canadian Engineer* for September 17th, 1914. As stated there, the whole line is expected to be ready to cope with its share of the western wheat crop in the course of a few weeks, at which time ballasting, and erection of buildings, etc., will have been completed.

NATIONAL TRANSCONTINENTAL RAILWAY
EASTERN DIVISION

MILEAGE BETWEEN PRINCIPAL POINTS

A. O. Cook
Asst to Chief Engineer.

— REVISED —
OTTAWA, ONT.
SEPT. 15th. 1914.

	Moncton	Halifax	Sydney	St John	McGivneys Jct	Napadogan	Edmundston	N.B. Boundary	Monk	Quebec Bridge N Abut	Bridge	Quebec via N T Ry	Hervey Jct	Fitzpatrick	Parent	Doucet	O'Brien	Que. & Ont Bound	Cochrane	Hearst	Grant	Armstrong	Superior Jct	Fort William	Graham	Redditt	Manitoba Bound	Transcona
MONCTON																												
HALIFAX (I.C.Ry.)	185.9																											
SYDNEY (I.C.Ry.)	337.6	276.4																										
ST. JOHN (I.C.Ry.)	89.4	275.2	427.5																									
McGIVNEYS Jct	96.3	282.2	433.9	185.7																								
NAPADOGAN	117.4	303.3	455.0	206.8	21.1																							
EDMUNDSTON	230.5	416.4	568.1	319.9	134.2	113.1																						
N.B. BOUNDARY	256.3	442.2	593.9	345.7	160.0	138.9	25.8																					
MONK	354.4	540.3	692.0	443.8	258.1	237.0	123.9	98.1																				
QUEBEC BRIDGE N ABUT	460.2	646.1	797.8	549.6	363.9	342.8	229.7	203.9	105.6																			
BRIDGE	460.6	646.5	798.2	550.0	364.3	343.2	230.1	204.3	106.2	0.4																		
QUEBEC VIA NTRy (Champlain Market)	466.7	652.6	804.3	556.1	370.4	349.3	236.2	210.4	112.3	6.5	6.1																	
HERVEY Jct	532.9	718.8	870.5	622.3	436.6	415.5	302.4	276.6	178.5	72.7	72.3	78.4																
FITZPATRICK	586.6	772.5	924.2	676.0	490.3	469.2	356.1	330.3	232.2	126.4	126.0	132.1	53.7															
PARENT	705.5	891.4	1043.1	794.9	609.2	588.1	475.0	449.2	351.1	245.3	244.9	251.0	172.6	118.9														
DOUCET	808.5	994.4	1146.1	897.9	712.2	691.1	578.0	552.2	454.1	348.3	347.9	354.0	275.6	221.9	103.0													
O'BRIEN	915.3	1101.2	1252.9	1004.7	819.0	797.9	684.8	659.0	560.9	455.1	454.7	460.8	382.4	328.7	209.8	106.8												
QUE & ONT. BOUND	956.2	1142.1	1293.8	1045.6	859.9	838.8	725.7	699.9	601.8	496.0	495.6	501.7	423.3	369.6	250.7	147.7	40.9											
COCHRANE	1027.9	1213.8	1365.5	1117.3	931.6	910.5	797.4	771.6	673.5	567.7	567.3	573.4	495.0	441.3	322.4	219.4	112.6	71.7										
HEARST	1156.9	1342.8	1494.5	1246.3	1060.6	1039.5	926.4	900.6	802.5	696.7	696.3	702.4	624.0	570.3	451.4	348.4	241.6	200.7	129.0									
GRANT	1282.1	1468.0	1619.7	1371.5	1185.8	1164.7	1051.6	1025.8	927.7	821.9	821.5	827.6	749.2	695.5	576.6	473.6	366.8	325.9	254.2	125.2								
ARMSTRONG	1413.5	1599.4	1751.1	1502.9	1317.2	1296.1	1183.0	1157.2	1059.1	953.3	952.9	959.0	880.6	826.9	708.0	605.0	498.2	457.3	385.6	256.6	131.4							
SUPERIOR Jct	1546.1	1732.0	1883.7	1635.5	1449.8	1428.7	1315.6	1289.8	1191.7	1085.9	1085.5	1091.6	1013.2	959.5	840.6	737.6	630.8	589.9	518.2	389.2	264.0	132.6						
FORT WILLIAM (G.T.P. Branch)	1738.1	1924.0	2075.7	1827.5	1641.8	1620.7	1507.6	1481.8	1383.7	1277.9	1277.5	1283.6	1205.2	1151.5	1032.6	929.6	822.8	781.9	710.2	581.2	456.0	324.6	192.0					
GRAHAM	1552.5	1738.4	1890.1	1641.9	1456.2	1435.1	1322.0	1296.2	1198.1	1092.3	1091.9	1098.0	1019.6	965.9	847.0	744.0	637.2	596.3	524.6	395.6	270.4	139.0	6.4	198.4				
REDDITT	1675.7	1861.6	2013.3	1765.1	1579.4	1558.3	1445.2	1419.4	1321.3	1215.5	1215.1	1221.2	1142.8	1089.1	970.2	867.2	760.4	719.5	647.8	518.8	393.6	262.2	129.6	321.6	123.2			
MANITOBA BOUNDY	1712.0	1897.9	2049.6	1801.4	1615.7	1594.6	1481.5	1455.7	1357.6	1251.8	1251.4	1257.5	1179.1	1125.4	1006.5	903.5	796.7	755.8	684.1	555.1	429.9	298.5	165.9	357.9	159.5	36.3		
TRANSCONA	1799.2	1985.1	2136.8	1888.6	1702.9	1681.8	1568.7	1543.9	1444.8	1339.0	1338.6	1344.7	1266.3	1212.6	1093.7	990.7	883.9	843.0	771.3	642.3	517.1	385.7	253.1	445.1	246.7	123.5	87.2	
WINNIPEG (Water Street)	1804.5	1990.4	2142.1	1893.9	1708.2	1687.1	1574.0	1549.2	1450.1	1344.3	1343.9	1350.0	1271.6	1217.9	1099.0	996.0	889.2	848.3	776.6	647.6	522.4	391.0	258.4	450.4	252.0	128.8	92.7	5.3

Editorial

A NEW PHASE OF WAR ENGINEERING.

The part played by engineering in the present European conflict is something for the details of which we may be obliged to wait a considerable length of time. The continual shifting of positions by the contending armies, however, impress us as sufficient to require a most remarkable manipulation of guns and supplies over rough country whose transportation routes have already been blocked and destroyed. This work falls naturally to the military engineers.

An outstanding feature of the methods of transportation and communication is the extensive use of the motor truck. It has brought about a revolution in transportation methods and has made possible the manoeuvring of millions of men and the required equipment of various classes of guns, ammunition, provisions, etc. These trucks are, for the most part, of ordinary type. This we know from the knowledge that Germany, France and England have systematically subsidized motor trucks during recent years on condition that they be available for governmental use in case of need. In Germany the subsidy amounted to $2,000, one-half of which was applied to the purchase price, and $250 of which was applied on upkeep yearly for four years. These trucks were to have a capacity of 6½ tons, to run 10 miles an hour with full load, to climb a 10% grade, and to haul one, or, if necessary, two trailers. At the beginning of 1912 over 800 trucks had been subsidized and the number has very greatly increased since that time, the government having power to requisition every motor vehicle in the German Empire.

In France a subsidy of $600 toward purchase, and $200 a year for three years toward upkeep, could be obtained from the government by owners of trucks of capacity of over three tons.

Great Britain allows a subsidy varying from $40 to $60 per vehicle and $75 a year for upkeep. Austria also subsidizes motor trucks and has a right to take possession in times of need.

The result is that motor trucks are brought into commission in almost every conceivable way for the rapid transportation of men and supplies. Artillery is, to a considerable extent, hauled by motors. This applies particularly to big motors such as constitute the heavy siege artillery. Many of these guns are known to weigh from 8 to 20 tons, while it is stated that there are larger pieces weighing 40 tons each, and at least as much more for the gun carriage. The projectile which such a gun uses weighs approximately a ton. It is evident that the transportation of these pieces of artillery, together with their ammunition supply, over stretches of country where there are no railroad facilities and whose bridges, etc., have been previously destroyed, is an engineering task that requires utmost skill, as the manipulation has to be prompt and absolutely reliable, since there may be depending upon the service armies of hundreds of thousands of men.

It is interesting to note that the Canadian expeditionary force at present on its way to Great Britain possesses an extensive motor equipment, including motors for mechanical transport, armoured cars with machine-guns, motor-drawn trucks, motor ambulances, touring cars for the officers and an armoured motor machine shop. This shop is very complete in itself with a full equipment of tools and lathes.

The problem of transportation is sufficiently gigantic of itself to evidence the dependence of military manoeuvres upon the engineering corps. There are other problems, such as those of entrenchments and fortifications, of water purification and sanitation—problems that are of an impromptu nature requiring immediate solution, thereby differing from the engineering that has already made itself evident in the design and construction of artillery pieces, ammunition, etc., while the world was yet at peace.

OPPORTUNITY FOR CANADIAN ELECTRICAL MANUFACTURERS.

Canadian exports of electrical apparatus amounted last year to $215,546. Imports, on the other hand, amounted to $9,098,736. At the present time there is a scarcity in England of electrical apparatus. It is only a few days ago that a newly established foreign trade commission in Pittsburgh, Pa., had a communication from a large engineering equipment house in London, England, stating that owing to the war its orders could not be filled and asking to be put in touch with Pittsburgh firms supplying all kinds of electrical equipment and machinery.

In view of the above figures of Canadian foreign trade in electrical apparatus, it is somewhat improbable for Canada to hope to export largely to Great Britain unless her productive capacity is materially increased. That Britain, whose supplies from Germany in this line amounted last year to £721,078 will have to look elsewhere should be an inducement of no small magnitude to Canadian manufacturers of electrical machinery and apparatus. The portion of the demand that might be supplied in this country is small, perhaps, in proportion to that which the United States is prepared to look after. Last year Great Britain's imports of these supplies from the United States attained a value of £437,906. Canadian manufacturers, however, should give the problem their very careful consideration at the present time. There is undoubtedly a market and that market is a country with which we are more closely associated than any other.

TRANSFER OF LOCOMOTIVE CONTRACTS.

Owing to the European war and the immediate cessation of trade relations with Germany the supply of railway locomotives and rolling stock, for which Germany has long been a keen contender, is rapidly undergoing a change in its source of manufacture. Before war broke out the leading German companies had in hand some enormous orders from British and overseas railways. One of the most important contracts comprises a large number of passenger carriages for the new electrified services around Buenos Ayres of the Central Argentine Railway Company. This contract was originally placed with a Hanover firm, but has now been awarded to the

Metropolitan Amalgamated Railway Carriage Company, of Birmingham.

South Africa and New Zealand had large orders for locomotives with the Maffic Company, of Munich. The Hanover company were also building thirty-four passenger carriages for the Union of South Africa railways.

Kersckel of Casel had orders for eighteen heavy main line engines for South Indian and some Argentine railways.

The Hanover Machine factory was building locomotives for the Bengal railway and Taff Vale railway, and the Hohenzollern works at Dusseldorff were building six powerful shunting locomotives for the Port of London authorities.

All these contracts now have been cancelled and shortly will be divided amongst British and American engineers.

AMERICAN ROAD BUILDERS' CONVENTION, CHICAGO.

The programme committee of the American Road Builders' Association reports that plans for the 11th Annual Convention to be held in Chicago, Dec. 14-18, are near completion. The general features of the programme have been decided upon, practically all of the subjects have been chosen and the assignment of speakers is now being made.

Registration will be carried on throughout Monday afternoon and evening. The forenoon of Tuesday, Dec. 15, will be devoted to the reception of delegates and visitors and to committee meetings, other preliminary business and the inspection of exhibits. At 2.30 p.m. the Congress will be formally called to order by President W. A. McLean, Provincial Highway Engineer of Ontario, and addresses of welcome will be given by officials of the city of Chicago, the state of Illinois, the Illinois Highway Commission, the University of Illinois, the Illinois Society of Civil Engineers and Surveyors, and the Illinois Highway Improvement Association.

The technical sessions will commence on Wednesday, and will be held each morning and afternoon until the close of the convention. On Wednesday evening, the Association will hold its annual dinner.

Essentially the same plan for the programme as that adopted at recent conventions of the Association will be followed. The various subjects to be treated have been so chosen as to cover the important phases of the three general divisions of the subject of highway work: Organization, Construction and Maintenance. Each topic will be introduced by a short paper presented by an authority especially selected for his knowledge of the subject on which he will speak. The discussion on that topic will then be opened by an especially selected speaker, who will be followed by other speakers, also selected because of their familiarity with the subject. The discussion will then be open for anyone who chooses to take part.

Among the topics to be treated are the following:—"Road and Pavement Dimensions—Widths, Depths and Crown;" "Road Foundations—Concrete, Telford, Gravel, etc.;" "Organization;" "Traffic—Present Tendencies, Probable Development and Regulation;" "Machinery for Construction and Maintenance;" "Brick Roads and Streets;" "Surface or Floors for Bridges;" "Bituminous Construction and Maintenance—Recent Practice;" "Concrete Roads;" "Recent Practice in the Construction of Wood and Granite Block Pavements;" "Earth and Gravel Road Construction;" "Street Paving in Small Cities;" "Convict Labor in Road Construction," and "Dust Prevention and Street Cleaning."

STEEL PRODUCTION IN CANADA, 1913.

PRODUCTION of all kinds of steel ingots and castings in Canada in 1913 amounted to 1,042,503 gross tons, an increase of 189,472 tons above 1912, according to the report issued by the American Iron and Steel Institute. Of the 1913 production, 1,006,149 tons were ingots and 36,354 tons were direct steel castings, being respective increases above 1912 of 185,357 and 4,115 tons.

The total productions of steel ingots and castings has increased rapidly in recent years, and the 1913 output was by far the largest in the history of Canada.

A table covering the production by both classes in gross tons, during the last ten years, follows:

Years.	Ingots.	Castings.
1913	1,006,149	36,354
1912	820,792	32,239
1911	768,559	22,312
1910	723,002	18,922
1909	664,789	13,962
1908	500,300	9,657
1907	629,026	17,728
1906	555,913	14,976
1905	394,955	9,394
1904	142,279	6,505

Plants Involved.—In 1913 there were sixteen steel works engaged in the manufacture of ingots or castings, compared with fourteen in 1912. There were four idle works in 1913, compared with three in 1912. In regard to processes, the production of Bessemer steel ingots and castings in 1913 was 273,391 tons, an increase of 65,822 above 1912. The output of open-hearth steel ingots and castings in 1913 amounted to 768,663 tons, which was 123,601 above 1912. Nearly all Bessemer steel made in the last two years was in the form of ingots. Of the 1913 open-hearth production, 736,562 tons was in ingots and 32,101 in castings.

The production of all kinds of finished rolled iron and steel in 1913 amounted to 967,097 tons, an increase of 105,873 tons, and also was the largest in the Dominion's history. Of last year's output about 95,881 tons were iron and 871,216 steel.

Finished Iron and Steel.—The production of all kinds of finished rolled iron and steel, in gross tons, by provinces, during a two-year period, follows:

Provinces.	1913.	1912.
Nova Scotia	380,488	337,466
Quebec	72,439	88,172
Ontario	504,900	418,346
New Brunswick, Alberta, Manitoba	9,270	17,240
Total	967,097	861,224

In 1913 there were twenty-one works engaged in rolling finished forms of iron and steel, and also the same number in the previous year. There were five idle rolling mills and steel works in 1913, compared with four in 1912. Three new steel plants were built in 1913, all equipped to make steel castings but not rolled iron or steel products. At the close of 1913 three additional similar plants were in course of being constructed.

Assurance comes from New York city that Tramways, Limited, the company which proposes to build the interurban line in the Edmonton district, announces that it is prepared to proceed with the project as soon as arrangements can be finally completed by the Edmonton city council for that construction.

Coast to Coast

Montreal, Que.—The taking over of the Montreal Water and Power Company is still a live question in the city of Montreal.

Sarnia, Ont.—Water from the new Sarnia waterworks plant on the lake shore is now flowing through the new mains into the city.

Peterborough, Ont.—On September 24, the distributing system of the Peterborough Light and Power Company passed into the possession of the city of Peterborough.

Fort William, Ont.—The net earnings of the Kaministiquia Power Company for the first 8 months of 1914 are announced as $185,295, with a surplus for the same period of $126,479.

Kingston, Ont.—What is said to be the most modern sewerage system in America has just been installed at the Rockwood Asylum for the Insane, Kingston. It was formally opened on September 19th by Dr. A. Amyot and J. A. Dallyn of the provincial department of public health.

Winnipeg, Man.—Though the contracts amounting to approximately $6,000,000 have just been awarded in connection with the Shoal Lake water supply project for Winnipeg, the work on the five various contracts totalling the stated amount will not be commenced until next May.

Selkirk, Man.—The public works under construction by the Dominion Government, which are being continued in spite of war conditions, are the new $100,000 drydock to accommodate the shipping on the Red river, and a $150,000 steel boat to serve as a fishing patrol on Lake Winnipeg, which is to be completed by June, 1915.

Winnipeg, Man.—The report of works completed thus far this year in the city of Winnipeg shows a long list of large paving works in asphalt No. 1, asphalt No. 2, concrete, and other pavements, sewers, walks, and various local works. The report further details important works yet under construction in sewers and pavements, as well as an extensive list of smaller works of all kinds throughout the city, either finished or now in the final stage of completion.

West Kildonan, Man.—Extensive public improvements have been conducted this year in West Kildonan. These include a 6-foot granolithic sidewalk on Main street from the city limits of Winnipeg to Kildonan Park; the laying of a portion of the two miles of 12-foot trunk sewer, which is to be completed from the river along Jefferson avenue by 1917; paving on North Main street for a distance of about 1½ miles; and a sewer to drain this 24-foot paved street which will be laid as soon as the paving is completed.

Prince Rupert, B.C.—It is expected that by the beginning of 1915 six of the great pontoons which are to be used in the construction of the G.T.P. floating dock at Prince Rupert, will have been completed. The first of these was launched about two weeks ago at the northern terminal. To build this 300,000 feet of lumber were used, besides tons of iron bars, bolts, nails and other fixtures required; and it is 130 feet in length. There will be 12 pontoons in all in this great dock, which will require 3,600,000 feet of lumber, not to speak of the many thousand extra feet will be necessary for the sides of the floating shipyard. The capacity of the new dock will be 20,000 tons, which means that it will be able to lift the largest warships or mercantile ships which ply the Pacific Ocean. The dock is so arranged that it can be used as three separate units or in any combination that is desired. The dock will probably be completed some time next year. Most of the piers in connection with the plant have been erected, and the buildings are now almost completed.

Toronto, Ont.—The work of dredging sewer outlets in Toronto harbor for the Toronto harbor commissioners, the contract for which was awarded to Mr. John E. Russell, has been about three-quarters completed. The work consists of dredging material which has been deposited in the slips along the waterfront through the sewers, and of conveying the matter dredged into the lake a distance of 10 miles and of dumping it there. The other work in connection with the harbor improvements being carried out this year by the commissioners, is making very substantial progress under the contractors, The Canadian Stewart Company. Both the ship channel, which is to serve the industrial district being created in the old Ashbridge's Bay, and the dock structures along the west face of this district, are well under way. Also work is being carried on rapidly from both the east and west ends and working towards the centre in the placing of cribs as a foundation for the seawall which is to protect the shore from the foot of Bathurst street west to the Humber river. Approximately $1,500,000 will be spent on this work during the year 1914.

Winnipeg, Man.—According to the recent progress report furnished to the meeting of the board of the Greater Winnipeg Water District, the field staff at work on the Shoal Lake water supply scheme was engaged in laying out and measuring up railway grade, track-laying, ballasting and drainage work. Up to August 31st, delivery had been taken of 266,879 railway ties, or 97 per cent. of the total order; telephone lines had been strung along a distance of 82.89 miles, leaving a balance of 11.89 miles to complete; 8,415½ long ton steel rails had been delivered, or 84 per cent. of the total tonnage required; 1,004,176 lbs. of splice bars had been delivered, completing the order pending an adjustment of the quantities shipped; 52 per cent. of the estimated total of necessary railway construction was under excavation; track-laying had been completed on 29.196 miles or on 29 per cent. of the estimated total; 12½ miles of the right-of-way had been fenced; 2,536 acres of the right-of-way had been cleared; division engineers' residences were practically completed; and 115,664 cubic yards of material were placed in the Falcon river dike, or 47 per cent. of the total required.

Winnipeg, Man.— An official announcement by the Greater Winnipeg Water District administration states that half of the Falcon river dyke at the Shoal Lake end of the water supply aqueduct, being constructed by Tomlinson and Flemming at a cost of $120,700, has been completed. This undertaking requires an embankment 5,070 feet long; and a channel 3,300 feet long, 35 feet wide, and 7 feet deep. For the former 170,000 cubic yards of sand and gravel, 12,000 cubic yards of riprap, and 5,000 feet of trestle will be used. For the latter 30,000 cubic yards of earth is to be removed. These operations are carried out to avoid the dark-colored water discharged by the river and to cut off the shallow flowage at the extreme westerly end of Indian Bay. The dyke is being built across the end of the bay, and a canal constructed therefrom to Snowshoe bay. It will be curved a mile long, and be a substantial embankment of sandy and gravelly material, raised 4 feet above the high-water level of the lake and protected on the exposed side with a heavy facing of riprap. A gate and screen chamber on the shore will be built; and to protect the intake from material drifting along the shore, piers will be constructed 150 feet out into the lake at each end of the receiving hole. A submerged conduit is also planned to bring the water from a point at least 150 feet from the shore. The gate and screens have been designed with liberal areas for sluice-gate openings and for screens, so as to cause as little fall of the water from the bay to the aqueduct as possible. There will be at least two sluice-gates, not less than 5 feet wide, and 6 feet high; and the screens will have a total length of not less than 50 feet, and a height extending from the bottom of the aqueduct

to the surface of the water. At the Falcon river crossing, a pile foundation for 600 feet is to be constructed; and for 150 feet of this length it will be necessary to depress the aqueduct, so that its top will be low enough to permit the passage of water of the river and light-draft boats. The depressed portion will be reinforced with steel, and the concrete will be much thicker than under usual circumstances.

PERSONAL.

Hon. Dr. J. O. REAUME, Minister of Public Works in the Ontario Cabinet, has resigned.

Hon. FINLAY G. MACDIARMID has succeeded Hon. Dr. Reaume as Minister of Public Works for the Province of Ontario.

R. O. WYNNE-ROBERTS, consulting engineer, Regina, Sask., is on a trip east, visiting Toronto, Ottawa, Montreal and New York.

Hon. W. H. HEARST, Minister of Lands Forests and Mines for the Province, has been chosen to succeed the late Sir James Whitney as Premier of Ontario.

E. L. HORWOOD, Ottawa, has been appointed chief architect of the Department of Public Works. Mr. David Ewart, who for about forty years has been acting in that capacity, will be consulting architect.

H. C. GROUT, St. John, N.B., has been appointed general superintendent of the Atlantic Division of the C.P.R., succeeding Mr. Wm. Downie, resigned. Mr. Grout has been in the company's service since 1898.

Hon. Sir ADAM BECK, chairman of the Hydro-Electric Power Commission of Ontario, has retired from the Ontario Cabinet. It is understood that his desire is to devote as much time as possible to the affairs of the Commission.

H. A. WOODS, of Montreal, is acting as chief engineer of the Grand Trunk Pacific Railway Co., at Winnipeg, since the resignation of Mr. B. B. Kelliher. (See *The Canadian Engineer*, Sept. 10th, 1914.) The directors have decided not to appoint a successor at present.

Hon. I. B. LUCAS, Provincial Treasurer of Ontario, has been appointed a member of the Hydro-Electric Power Commission of Ontario, to succeed Lieut.-Col. Hon. J. S. Hendrie, whose appointment to the Lieutenant-Governorship of the Province left a vacancy on the Hydro Board.

Dr. T. KENNARD THOMSON, consulting engineer, New York City, has been appointed by Gov. Glynn, of New York State, a member of the Atlantic Deeper Waterways Commission. This commission, of which Hon. J. Hampton Moore is President, has under investigation a system of canals to extend from Florida to Maine, with a total length of between seven and eight hundred miles and at a probable cost of $35,000,000.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Council of the Canadian Society of Civil Engineers have announced that their fees for the year will be remitted to all members of the Society who have volunteered for service with the allied armies.

At its meeting on Sept. 9th the Council also resolved to establish a fund to be applied in aid of dependent members of families of Society members who have volunteered for active service in the army.

Premier McBride says that public works in the province will not be stopped, that construction will proceed on the railways in different sections, and that every effort will be made to sustain that confidence which has generally marked the people of British Columbia.

IRRIGATION PUMPS FOR EGYPT.

Some particulars have been recently made public regarding the pumps which are being supplied from England in connection with the irrigation work now being carried out in the Behira district.

The pumps are of the Humphrey pattern, similar to those at the Metropolitan Water Board's reservoir at Chingford, but incorporating some novel ideas. The valves, for example, are of a unique design, which permits them to shut fairly close even when a large obstruction fouls the seating. The pumps will be eight in number, with a total capacity of 792,000,000 gallons per 24 hours, and the lift to be provided for is from 19 ft. to 20 ft. The maximum internal diameter of the combustion chamber will be 8 ft. 8 in., and it will be about 14 ft. in height. The water valve box, which will be 7 ft. in height, will be 8 ft. 8 in. in diameter.

The gas for the pumps will be produced by an anthracite Mond plant, gasifying 44 tons per day, the plant consisting of nine producers, one of which is a spare. The plant is being supplied under a guaranteed consumption of 1.15 lb. of coal per water horsepower.

COMING MEETINGS.

MOTOR TRUCK CLUB OF AMERICA.—Annual Convention, Detroit, Mich., October 7th to 9th. President, George H. Duck, New York City.

GULF AND INTEROCEAN NATIONAL HIGHWAY ASSOCIATION.—October 8th, 9th, 10th; conference to be held at New Orleans, La. Secretary, Jno. B. Kent, Lake Charles, La.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.—Annual Convention, Grunewald Hotel, New Orleans, La. October 20th to 23rd. Secretary, Mr. McFall, Roanoke, Va.

ALABAMA GOOD ROADS ASSOCIATION.—Nineteenth Annual Convention will be held from October 21st to 23rd at Montgomery, Ala. Secretary, J. A. Rountree, 1021 Brown Marx Building, Birmingham, Ala.

NORTHWESTERN ROAD CONGRESS.—Annual Convention, to be held at Milwaukee, Wis., October 28th to 31st. Secretary, J. P. Keenan, Milwaukee.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Charles Carroll Brown, Secretary, Indianapolis, Ind. Meets at Somerset Hotel, Boston, Mass., October 21st, 22nd and 23rd.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

WASHINGTON STATE GOOD ROADS ASSOCIATION.—Convention to be held at Spokane, Wash., November 18th, 19th, and 20th. Secretary, M. D. Lechey, Alaska Building, Seattle, Wash.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

Volume 27. Toronto, October 15, 1914

Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

TRANSMISSION LINE CHARACTERISTICS

MECHANICAL CHARACTERISTICS OF COPPER AND ALUMINUM WIRES FOR ELECTRICAL TRANSMISSION LINES—SOME USEFUL TABLES, FORMULAS AND CHARTS.

By E. MAERKER, A.Sc.,
Designing Structural Engineer, Toronto.

VARIOUS tables and charts pertaining to electric transmission line wires have been compiled by different authors from time to time. These tables and charts enable the engineer in the field, when stringing the wire, to allow a certain tension at the prevailing temperature in order that the tension may not become excessive at some lower temperature and maximum loading; and on the other hand, to prevent the sag from becoming too great at some high temperature, which might reduce the clearance from ground to lowest point of wire beyond the specified limit.

In order to obtain a clear picture of how different temperatures and various loadings affect the tension and sag in the wire, Charts I. and II. have been constructed, the former for copper wire and the latter for aluminum.

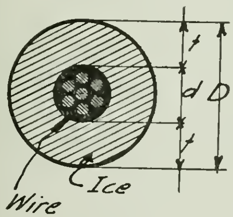


Fig. 1.

These diagrams are easily constructed and the values are read off directly, eliminating all shifting about on the paper with straight-edges, as would be the case with parallel-scale types and others. The following diagrams are based on the parabolic law, as no appreciable error is introduced by doing so, providing the span is within reasonable limits.

The loading on the wire depends, of course, on the climatic conditions. However, in temperate zones an ice loading of ½ inch in thickness at 0° F. in conjunction with a wind pressure of 8 lbs. per square foot of projected area of the wire, corresponding to a 70-mile indicated wind velocity, or 55.2 actual, is usually recommended as maximum loading.

To obtain the weight of ice per foot of wire, the author has derived the following formula, which will undoubtedly be of some value.

Taking the ice as 57.3 lbs. per cu. ft., we have for W, the weight of ice per foot of wire:

$$W = \frac{\frac{D^2\pi}{4} - \frac{d^2\pi}{4}}{144} \cdot 57 \cdot 3 = \frac{57 \cdot 3 \cdot \pi}{4 \cdot 144} (D^2 - d^2)$$

Substituting $d + 2t = D$, we have:

$$W = \frac{57 \cdot 3 \cdot \pi}{144} \cdot (dt + t^2) = \frac{5}{4}\, t\, (d + t) \qquad (1)$$

where t denotes the thickness of the ice coating, and d the diameter of the wire; all values being in inches.

Combining the weight of the wire plus the ice with the wind, the resultant force acting on the wire is thus obtained, which forms the basis to all further calculation.

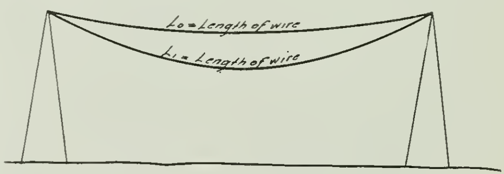


Fig. 2.

Development of Equations.

Let a denote the area of the wire in square inches.
w_0 " the resultant force per foot of wire under maximum loading at 0° F., in lbs.
$w_1 w_2 w_3$ " the resultant force per foot of wire under different loading, in lbs.
l " the span in feet.
S_0 " the sag at midspan under maximum loading at 0° F., in feet.
S_1 " the sag at midspan under different loading, in feet.
P_0 " the pull or tension in the wire under maximum loading at 0° F., in lbs.
P_1 " the pull or tension in the wire under any loading or at any temperature, in lbs.
L_0 " length of wire at maximum loading at 0° F., in feet.
L_1 " length of wire at any other loading and other temperature.
α " coefficient of linear expansion.
t " temperature in degrees of Fahrenheit.
E " Modulus of elasticity in lbs. per sq. in.

Fig. 2 shows two rigid supports and a wire suspended between these supports. Let L_0 represent the length of the wire under maximum loading; *i.e.*, under a loading equal to the resultant of the dead load of the wire plus the weight of ½ inch of ice and a wind pressure of 8 lbs. per square foot of projected area of ice-covered wire at a temperature of 0° F.

Evidently this wire is undergoing a change in length at some other temperature and different loading. A simultaneous change of temperature and loading is more complicated, but by letting the loading remain constant for the time being, calculating the change in length due to the temperature only and finally combining this with the change due to the different loading, the total change in the length is easily found.

Let L_1 (Fig. 2) be this changed length of the wire. The effect of the temperature is always partly counterbalanced by the effect of the change in tension. A higher temperature will stretch the wire and increase the sag. This increased sag in turn will diminish the tension and cause a shortening in the length. The algebraic sum of these changes will be the actual change in the length. The author has seen several charts which do not take account of this change due to the tension, caused by the change of temperature. This factor is quite an appreciable one, even with moderate spans.

Let $L_0 \alpha t$ be the linear expansion due to the rise in temperature t, then $L_0 (1 + \alpha t)$ would be the total length of the wire, providing the tension would remain the same. Since, however, the tension becomes less with the increase in length, the shortening has to be added algebraically to the above value $L (1 + \alpha t)$, and the actual length is thus found. In order to derive an expression for this shortening in the length, we have to employ following fundamental formula:

$$\text{Modulus of elasticity } E = \frac{\text{unit stress}}{\text{unit strain}} = \frac{P_0/a}{e_0/L_0} = \frac{P_1/a}{e_1/L}$$

and by transposing $e_0 = \dfrac{P_0 L_0}{a E}$ and $e_1 = \dfrac{P_1 L_1}{a E}$ where e_0 and e_1 represent the linear deformation due to the tension P_0 and P_1 respectively.

The total difference is

$$L_1 - L_0 = L_0 \alpha t + e_1 - e_0; \text{ or,}$$

$$L_1 - L_0 = L_0 \alpha t + \frac{P_1 L_1 - P_0 L_0}{a E} \qquad (2)$$

Transposing: $P_1 L_1 = L_1 a E - L_0 a E - L_0 \alpha t a E + P_0 L_0$

Dividing by L_1; $P_1 = a E - \dfrac{L_0}{L_1} aE - \dfrac{L_0}{L_1} \alpha t a E + \dfrac{L_0}{L_1} P_0$;

$$\text{or, } P_1 = \frac{L_0}{L_1} [P_0 - a E (1 + \alpha t)] + a E$$

The general expression for the length of the wire in terms of the sag is $L = l + \dfrac{8 S^2}{3 l} = \dfrac{3 l^2 + 8 S^2}{3 l}$, and substituting for L_0 and L_1 we have

$$P_1 = \frac{3 l^2 + 8 S_0^2}{3 l^2 + 8 S_1^2} [P_0 - aE (1 + \alpha t)] + a E \qquad (3)$$

which is the formula used for compiling Table II. Here we notice that three variables are involved in this equation, P_1, S_1 and t. By giving t a certain value and assume different values for S_1, we obtain corresponding values for P_1 which can be plotted. The P_1 values are plotted on the vertical axis and the S_1 values on the horizontal axis. By repeating this operation and assigning another certain value for t, we obtain a family of curves. This operation renders t a variable parameter.

Since we have two variables now and only one equation, we have to establish some other relation between P_1 and S_1. This is accomplished by using the well-known formula

$$P_1 = \frac{w l^2}{8 S_1} \qquad (4)$$

The value w represents the variable parameter.

Table I. has been worked out for a copper wire of 250,000 C.M. and a span of 600 feet. The values are taken from the reports of the National Electric Light Association, 36th convention:

Table I.—Stranded Hard-drawn Copper Wire of 250,000 C.M.

Area in circular mills	250,000 or a = .19635 sq. ins.
Elastic limit	35,000 lbs. per square inch.
Elastic limit	6,870 lbs. per wire.
Allowable tension...	30,000 lbs. per square inch.
Allowable tension...	P_0 = 5,900 lbs. per wire.
Ultimate strength ..	60,000 lbs. per square inch.
Ultimate strength ..	11,790 lbs. per wire.
Modulus of elasticity	$E = 16 \times 10^6$ lbs. per sq. in.
Coefficient of linear expansion	$\alpha = 96 \times 10^{-7}$
Weight per ft. of wire plus ½ in. ice and 8 lbs. wind.........	w_0 = 1.788 lbs.
Weight per ft. of wire, no ice, no wind....	w_1 = .762 lbs.
Weight per ft. of wire, no ice, 15 lbs. wind	w_2 = 1.061 lbs.
Weight per ft. of wire, ½ in. ice, no wind	w_3 = 1.440 lbs.

Above values are substituted in equation (3).

$$P_1 = \frac{3 l^2 + 8 S_0^2}{3 l^2 + 8 S_1^2} [P_0 - a E (1 + \alpha t)] + a E$$

$$l = 600; \ 3 l^2 = 1{,}080{,}000$$

$$S_0 = \frac{w_0 l^2}{8 P_0} = \frac{1.788.360000}{8.5900} = 13.637; \ 8 S_0^2 = 1{,}487.75$$

$$3 l^2 + 8 S_0^2 = 1{,}080{,}000 + 1{,}487.75 = 1{,}081{,}488$$

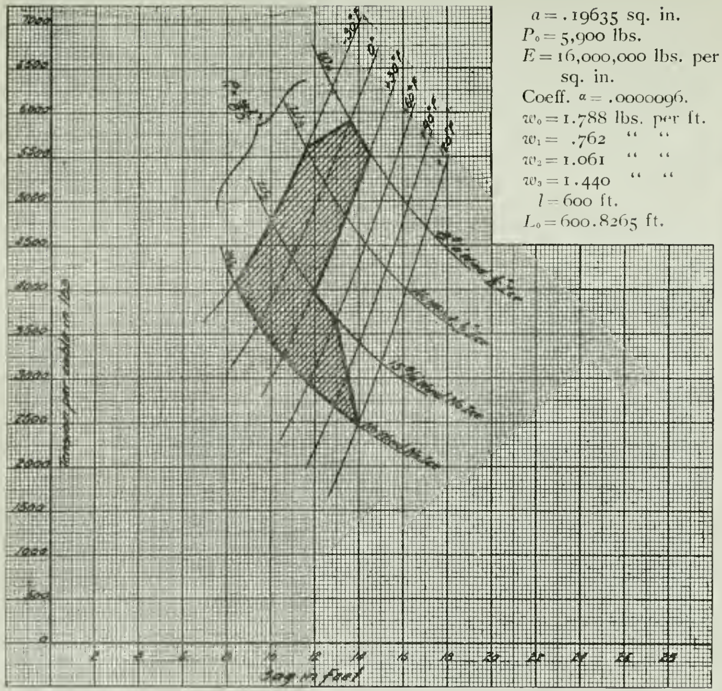
$$a E = .19635 \times 16{,}000{,}000 = 3{,}141{,}600$$

Table II. gives values for P_1 and S_1 which can be plotted now.

In order to plot equation 4, which furnishes points of intersections with above curves, Table III. has been compiled.

Having plotted all these values for P_1 and S_1, we obtain an exact picture of the behavior of the wire at various temperatures and under different loadings. It will be noticed that equation (3) is rather lengthy and cumbersome. By making a slight change in this equation the whole computation is materially shortened without affecting the results appreciably. This is accomplished by substituting L_0 for L_1 in equation (2) on the right side only, as shown $L_1 - L_0 = L_0 \alpha t + \dfrac{P_1 - P_0}{a E} L_0$

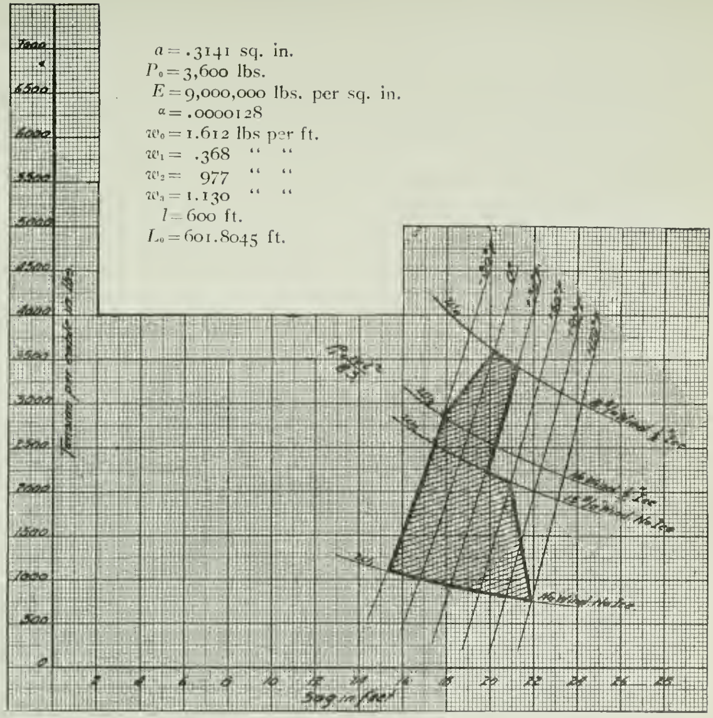
Solving for P_1 we get $P_1 = P_0 + a E \left[\dfrac{L_1}{L_0} - 1 - \alpha t\right]$



$a = .19635$ sq. in.
$P_0 = 5{,}900$ lbs.
$E = 16{,}000{,}000$ lbs. per sq. in.
Coeff. $\alpha = .0000096$.
$w_0 = 1.788$ lbs. per ft.
$w_1 = .762$ " "
$w_2 = 1.061$ " "
$w_3 = 1.440$ " "
$l = 600$ ft.
$L_0 = 600.8265$ ft.

Chart I.—Showing Tension and Sag of 250,000 C.M. Hard-drawn Copper Cable at Various Temperatures and Under Different Loading; 600-ft. Span.

$$P_1 = P_0 + a E \left[\frac{8 S_1^2}{3 l L_0} + \frac{l}{L_0} - 1 - \alpha t^\circ\right]$$



$a = .3141$ sq. in.
$P_0 = 3{,}600$ lbs.
$E = 9{,}000{,}000$ lbs. per sq. in.
$\alpha = .0000128$
$w_0 = 1.612$ lbs per ft.
$w_1 = .368$ " "
$w_2 = 977$ " "
$w_3 = 1.130$ " "
$l = 600$ ft.
$L_0 = 601.8045$ ft.

Chart II.—Showing Tension and Sag of 400,000 C.M. Aluminum Cable at Various Temperatures and Under Different Loading; 600-ft. Span.

$$P_1 = P_0 + a E \left[\frac{8 S_1^2}{3 l L_0} + \frac{l}{L_0} - 1 - \alpha t^\circ\right]$$

Table II.

Temperature "t"

	— 30°	0°	+ 30°	+ 60°	+ 90°	+ 120°
$1 + \alpha t$	.999712	1.000000	1.000288	1.000576	1.000864	1.001152
$a E (1 + \alpha t)$	3,140,695	3,141,600	3,142,505	3,143,410	3,144,315	3,145,220
$P_0 - a E (1 + \alpha t)$ (neg.)	3,134,795	3,135,700	3,136,605	3,137,510	3,138,415	3,139,320
$\log [P_0 - a E (1 + \alpha t)]$	6.4962091	6.4963345	6.4964598	6.4965851	6.4967104	6.7968356
$\log (3 l^2 + 8 S_0^2)$	6.0340217	6.0340217	6.0340217	6.0340217	6.0340217	6.0340217
$\log [(3 l^2 + 8 S_0^2)\{P_0 - aE(1 + \alpha t)\}]$	12.5302308	12.5303562	12.5304815	12.5306068	12.5307321	12.5308572

Sag in feet = S_1

	t	6	8	10	12	14	16	18	20
$3 l^2 + 8 S_1^2$		1,080,288	1,080,512	1,080,800	1,081,152	1,081,568	1,082,048	1,082,592	1,083,200
$\log (3 l^2 + 8 S_1^2)$ ...		6.0335396	6.0336296	6.0337453	6.0338868	6.0340538	6.0342465	6.0344648	6.0347087
Tension P_1 in lbs.	— 30°	3,324	3,974	4,809	5,820	7,037	8,427	10,002	11,757
	0°	2,417	3,067	3,904	4,920	6,132	7,522	9,097	10,857
	+ 30°	1,511	2,162	3,000	4,021	5,227	6,618	8,193	9,953
	+ 60°	605	1,256	2,093	3,115	4,322	5,714	7,290	9,050
	+ 90°	— 303	350	1,187	2,210	3,417	4,809	6,385	8,140
	+ 120°	— 1,209	— 555	282	1,305	2,513	3,905	5,482	7,243

Table III.—Copper Wire.

$$P_1 = \frac{w l^2}{8 S_1}$$

Sag in feet = S_1

			6	8	10	12	14	16	18	20
Tension P_1 in lbs.	$w_0 = 1.788$,	8 lb. wind; ½″ ice	13,437	10,078	8,046	6,710	5,745	5,028	4,470	4,023
	$w_1 = .762$	No wind; no ice..	5,715	4,286	3,429	2,855	2,450	2,145	1,905	1,715
	$w_2 = 1.061$	15 lb. wind; no ice	7,958	5,968	4,775	3,980	3,410	2,985	2,656	2,387
	$w_3 = 1.440$	No wind; ½″ ice.	10,800	8,100	6,480	5,400	4,625	4,050	3,600	3,240

Table IV.—Copper Wire.

$$P_1 = 23.239 S_1^2 + 1,580 - 30.16 t$$

Sag S_1 in feet.

	Temp. t	6	8	10	12	14	16	18	20
Tension P_1 in lbs.	— 30°	3,322	3,972	4,809	5,831	7,040	8,434	10,014	11,780
	0°	2,417	3,067	3,904	4,926	6,135	7,529	9,109	10,876
	+ 30°	1,512	2,162	3,000	4,021	5,230	6,624	8,204	9,971
	+ 60°	607	1,257	2,095	3,116	4,325	5,719	7,300	9,065
	+ 90°	....	352	1,190	2,211	3,420	4,814	6,395	8,160
	+ 120°	....	....	285	1,306	2,515	3,909	5,490	7,255

Table V.—Aluminum Wire.

$$P_1 = 20.877 S_1^2 - 4875 - 36.18 t$$

Sag in feet = S_1

	Temp. t	12	14	16	18	20	22	24	26
Tension in lbs. P_1	— 30°	— 784	302	1,555	2,975	4,560	6,315	8,235	10,323
	0°	—1,869	— 783	470	1,890	3,476	5,230	7,150	9,238
	+ 30°	—2,954	—1,868	— 615	805	2,390	4,145	6,065	8,153
	+ 60°	....	—2,936	—1,700	— 280	1,306	3,060	4,980	7,068
	+ 90°	....	....	—2,785	—1,365	220	1,975	3,895	5,983
	+ 120°	....	....	....	....	— 864	890	2,810	4,898

Table VI.—Aluminum Wire.

$$P_1 = \frac{w l^2}{8 S_1}$$

Sag S_1 in feet.

			12	14	16	18	20	22	24	26
Tension P_1 in lbs.	$w_0 = 1.612$	8 lb. wind; ½″ ice	6,045	5,180	4,540	4,030	3,627	3,300	3,020	2,790
	$w_1 = .368$	No wind; no ice..	1,380	1,182	1,035	920	823	753	690	637
	$w_2 = .977$	15 lb. wind; no ice	3,664	3,140	2,748	2,440	2,198	1,997	1,830	1,690
	$w_3 = 1.130$	No wind; ½″ ice.	4,238	3,632	3,180	2,825	2,543	2,310	2,117	1,955

and substitute $l + \dfrac{8 S_1^2}{3 l}$ for L_1 we have

$$P_1 = P_0 + a E \left[\frac{8 S_1^2}{3 l L_0} + \frac{l}{L_0} - 1 - \alpha t\right] \quad - \quad - \quad (5)$$

which is the equation used for Charts I. and II. Chart I. is for copper wire and Chart II. for aluminum. Substituting the numerical values in above equation and letting $L_0 = l + \dfrac{8 S_0^2}{3 l}$, we obtain

$$P_1 = 5{,}900 + 23.239 S_1^2 - 4{,}321 - 30.16 t$$

or $$P_1 = 23.239 S_1^2 + 1{,}580 - 30.16 t$$

Chart I. is constructed from Tables III. and IV., and Chart II. from Tables V. and VI., using equations 4 and 5.

Comparing results of equations 3 and 5, it is seen that no appreciable error is introduced by adopting equation 5.

Tables V. and VI. are for aluminum wire. Size, weight, etc., are printed on Chart II.

The boundaries of the shaded area are the limitations to which the sag and the tension are confined. Since max. loading is specified at 0° F., the curve w_0 could not extend further to the left of the temperature curve of 0°, accounting for the edge chipped off in the left-hand upper corner. The ice limit at 32° F. shows the ice loading curves running outside along the 30° curve down to the w_2 loading curve. From there it runs along the latter curve to 60°, where a maximum wind of 15 lbs. is liable to occur. From here the line runs to the intersection of the w_1 curve with the 120° curve, *i.e.*, highest temperature with no ice and wind.

It is to be noticed from Chart I. that the maximum sag does not occur at the highest temperature, but at 30° with a maximum loading. These curves show very plainly what effect the temperature and the loading has upon the tension and the sag of the wire.

In Chart I. it is seen that a change in loading affects the tension more than the sag, while a temperature change has an equal effect on tension and sag. In Chart II. a change in loading is affecting the tension far more than the sag and a change in temperature has a greater effect upon the sag than the tension, especially noticeable with the w_1 curve.

[This article deals with spans of 600 feet only; in a later article Mr. Maerker will extend the information to include spans ranging from 200 to 1,000 feet.—EDITOR.]

NORTHERN WATER-POWERS.

The statement is sometimes made by the uninitiated that the water powers north of the settled parts of our Dominion are of little value. The existence of numerous falls and rapids in these parts is not denied, but the argument is advanced that the temperature and other climatic conditions existing where these falls and rapids are situated will prevent their utilization. As a direct contradiction to the above assertion, we need only turn to Norway, the latitude of which is about the same as that of the Yukon and where climatic conditions are similar to those of northern Canada. In size, Norway is only slightly larger than our Maritime Provinces, and yet we find their water-power plants with a total capacity of over 1,500,000 h.p., either in actual operation or in course of construction. Hydro-electric stations of considerable size have been constructed in different parts of that country. Many of the smaller ones have been erected for municipal use; but the larger ones are for the electrochemical industry, in which a main factor of success is cheap and plentified electric power.

AMERICAN PIG-IRON, ROLLED IRON AND STEEL.

The official statistics of American pig-iron production in the first half of 1914 make the following comparisons, in tons of 2,240 lbs.:—

	First half.	Second half.	Year.
1911	11,666,996	11,952,551	23,649,547
1912	14,072,274	15,654,623	29,726,937
1913	16,488,602	14,477,550	30,966,152
1914	12,536,094	....	....

Thus there was a decrease of 24 per cent. from the tonnage in the best half-year—the first half of 1913. An interesting feature in the statistics is that while the total production greatly decreased, the production of foundry iron was larger in the first half of this year than in the second half of last year. The explanation probably is that too much foundry iron was made in the first half of last year, while in the second half the stocks were liquidated, with unusually light production, and production this year returned to normal.

The production of rolled iron and steel in 1913 has just been officially reported, and we include in the table below the production of steel ingots, already reported for 1913:—

	Total rolled. Tons.	Rolled iron. Tons.	Rolled steel. Tons.	Steel ingots. Tons.
1911	19,039,171	1,460,615	17,578,556	23,029,479
1912	24,656,841	1,637,582	23,019,259	30,284,682
1913	24,791,243	1,678,257	23,112,986	30,280,130

The rolled material is reported in the form in which it suffered its last hot rolling, the material of course being sheared or cropped thereafter. Thus no billets or sheet bars are included, except those exported, plus rolled forging billets, while rods and skelp are returned as such, and blackplates rather than tinplates are included.

In the past two years the difference between steel ingots and rolled steel has averaged about 7,200,000 tons. A small part of this difference was absolutely lost, but the great bulk of the difference represented new scrap. In addition, there is new scrap produced in fabrication. A small tonnage of sheet mill scrap is used in charcoal forges, but in general there is indicated a supply of about 7,500,000 tons annually, which went to the open-hearth steel works, thus constituting 35 per cent. of the production of 21,599,931 tons of open-hearth steel ingots and castings. The production of basic pig-iron in 1913 was 12,500,000 tons, while there was perhaps 750,000 tons of Bessemer and low-phosphorus iron used in the acid open-hearth steel process. With these figures available, it is evident that the consumption of old scrap in the open-hearth process is really not large.

It is stated by Mr. J. H. Plummer, president of the Dominion Steel Works at Sydney, N.S., that indications point to a speedy resumption of operations of some of the mills of the works. Orders have already been received from England for 2,000 tons of nails and 2,000 tons of wire rods, and negotiations are pending regarding an order for rails.

Although the production of coal in North Dakota in 1913 was only 495,320 short tons, valued at $750,652, some interesting facts regarding the possibilities of the vast deposits which underlie the state are shown in a statement by E. W. Parker just made public by the United States Geological Survey. All the present mineral fuel produced in North Dakota is brown coal, or lignite. Considerable areas of sub-bituminous coal of usable quality and workable thickness are believed to underlie portions of the lignite areas, but no attempt to exploit the sub-bituminous coals has been made. At present the lignite is used chiefly for domestic purposes, but with proper equipment it can be used with satisfaction as a boiler fuel. A convincing example of what may be accomplished with lignite for such use is presented by the irrigation plant of the United States reclamation service at Williston. The lignite used here is taken from the only coal mine owned and operated by the Government. As the gas-producer and internal-combustion engines in large units come into more general use in the West, as they are rapidly doing in the East, the lignites of North Dakota will be recognized as possessing great potentialities in the settlement and economic development of the state. Experiments also show that lignite can be successfully briquetted, after which it stands transportation well and its heat value is increased 50 to 70 per cent.

MODERN FIXED AND INTERLOCKING RAILROAD SIGNALS.

RAILROAD signalling is the art of conveying information as to the occupancy or condition of the track ahead to an engineman or conductor in charge of a train so that he may move his train safely and expeditiously. It is obviously necessary for the train crew to have this information whenever more than one train is operated over the line at the same time. The means of conveying it are numerous, and include the time card, dispatcher's orders, precedence of one class of train over another, hand or lamp signals, and fixed signals.

A discussion of fixed signals, and the interlocking and other devices connected therewith is contained in a paper on railroad signalling read by H. J. Pfeifer, engineer maintenance of way, Terminal Railroad Association of St. Louis, before the Engineers' Club of St. Louis. From it the following notes are taken.

The end sought by all railroads, signal engineers, and the manufacturers of signal appliances is "Safety First." To be successful, however, in these times of dense traffic at high speeds, increased expense and low rates, a signal installation must have other qualities in addition, among which are facility, reliability, and economy.

In the early stages, attempts to secure safety and facility were more or less compromises between the two with sacrifices on the part of each. The advance of the art, however, has been so rapid of late years that less and less sacrifice is necessary. To secure safety and facility the signal mechanism must be reliable in operation; *i.e.*, subject to the minimum of failure.

True economy is not confined to the cost of installation, or even of maintenance and operation, but takes into account the entire conduct of the railroad and that system is the best in each case, which results in the safe movement of the traffic at the least gross expense, and in the shortest time, even though the signalling system is elaborate and costly in itself.

Fixed signals may be divided into two general classes, block and interlocking. The first are for the purpose of maintaining a proper space interval between trains on a given stretch of track, and the second for controlling the movement of trains at crossings, junctions and terminal points.

Block Signals.—Probably the simplest form of block signal is the train order board or simple manual block at a station which is under the control of an operator or agent. Information as to the condition of the line is transmitted to him by telegraph, and in recent years by the telephone. Ordinarily this board gives three indications, "Stop," "Proceed cautiously" because of train in block moving in same direction, (this order is usually given to freight trains only) and "Proceed," block is clear. The manipulation of the signal is entirely in the control of the operator, there being no connection between adjoining stations, except for the transmission of information. You will note that in the use of this system, collision or accident may result, through the unchecked action of at least three men or agencies: First, the operator at the station in advance, having overlooked the train in the block, may give false information; second, the operator may make a mistake and give a clear signal with a train in the block ahead, and third, the engineman may fail to obey a stop signal.

The danger of this lack of control over the operators resulted in the development of the controlled manual block. In this system the signal is locked in the stop position and cannot be cleared until released by the operator at the station in advance. After the passage of the train the signal automatically returns to the stop position. This system increases safety because a clear signal cannot be given, except by the concurrent action of two operators. There is nothing about it, however, reducing the danger resulting from the failure of the engineman to obey a stop signal.

An additional safeguard on single track lines is the electric train staff. In this system there are interlocked receptacles at each station containing staffs for delivery to the engineman. Not more than one staff can be taken out at one time, which is an assurance that there can be only one train in the block, as no train is permitted to enter unless the engineman has a staff. The staff is placed in a frame, adjacent to the track, similar to a mail catcher, out of which the engineman can take it if moving at a reasonably low rate of speed. As the train passes the advance block the staff is thrown off by the engineman and placed in its receptacle by the operator, after which it is again possible to withdraw a staff at either one end or the other. In addition to the main staff, provision is made for permissive staffs, which can be issued to following trains, and grant the right to enter the block under control and with the advice that block is already occupied. This gives great additional safety, because the key for unlocking the system is on the train itself and cannot be used until the train has cleared at either end. In this system also there is no mechanical device to check the engineman in case he fails to obey the signal.

The St. Louis tunnel, as an example, is operated on on an absolute controlled block, with a modified staff system added for eastbound freight trains only. On account of the smoke and darkness it is essential that not more than one train is on each track at one time.

The system consists of an interlocking machine at the west end of the tunnel, known as "X" office, and another at the east end known as "MS" office. They are a little more than a mile apart.

The two machines are connected by a system of electric locking which compels the co-operation of the operators at both ends before signals can be given which will permit a train to enter the tunnel. These signals, by means of track circuits, are automatically returned to the stop position behind the train accepting the proceed signal and entering the tunnel. The track circuit is in two sections of about 240 feet, one at each end of the tunnel. The signal automatically restored to the stop position and the signal governing in the opposite direction cannot again be cleared until the train has passed out of the tunnel. As an additional precaution there must be a red light on the rear end of each train. The operator at the outlet station must see this light and then record on his train sheet the hour and minute during which the train passed his station. There is a heavy grade eastward through the tunnel and it is possible that an eastbound freight train may break in two, and leave cars standing between the track circuits, without being noticed by either the engineman or the operator. As the forward part of the train would release the track circuit control, it is within the bounds of possibility for the operator to make a mistake, say, that he saw the red light on the rear end of the train, when he actually did not, and release the tunnel entrance signal at the west end for another train. The disastrous possibilities of the resulting collision with the cars in the tunnel led to the adoption, a few years ago, of the following device:

Before entering the tunnel the rear switchman on every freight train, who is compelled under the rules to ride on the rear end of the last car, is given a numbered leather disk by the yardmaster. This number is communicated to the dispatcher or operator at the west end of the tunnel. As the train passes "MS" office at the east end the rear switchman delivers this disk to the operator, who reports its number to the dispatcher at "X" office. Unless the number reported by the yardmaster and operator agree, no train is permitted to enter the tunnel until it has been found clear by a light engine feeling its way through.

Another form of block signal is the automatic, which is defined as follows in the Signal Dictionary:

"A block signal, worked by electric or pneumatic agency, which is controlled by the passage of a train into, through and out of the block section to which the signal is connected. The entrance of a train sets the home signal at stop, and the clearing of the block section by the passage of the train out of it sets that signal clear. The apparatus is so arranged that the misplacement of a switch or the accidental entrance of a car from a side track will set the signal at stop."

This result is accomplished by the use of the track circuit defined as follows in the same volume:

"An electric current flowing through the rails of a railroad track. In a typical track circuit, the current flows from the battery to the nearest rail of the track, thence to the other end of the track circuit section; thence by wire to the track relay (controlling a signal) back by a wire to the farther rail, and by that rail back to the battery. Each rail is made electrically continuous from one end of the track-circuit section to the other by metallic bonds at the joints, and at the ends of the section insulated joints are used."

Automatic signals have been in use in this country since 1871 with "track instruments" and since 1879 with "track circuits."

The first form of automatic signal was the enclosed disk or banjo type which is still used on some of the largest railroads. The day indications are given by the color or position of circular disks, and the night indications by the usual colored lenses.

Of late years the disk signal has been almost entirely superseded by the semaphore; defined as follows:

"A type of signal introduced on railroads in England about 1841 and now in almost universal use for both block and interlocking signals. It consists of an arm about 4 ft. long and 10 in. wide, mounted on a post usually 24 to 30 ft. high at one side of the tracks; or on a shorter post supported by a bridge or other structure above the track. Day indications are given by the position of the arm horizontal, inclined or vertical, and night indications by a light. The pivot of the arm is combined with a spectacle casting holding colored glass disks, which, as the position of the arm is changed, move in front of a lamp mounted on the post."

By far the largest portion of all automatic semaphore block signals are electric, although there are some electro-pneumatic and electro-gas signals.

In some of the earlier automatic installations, the signal indicated the condition of the track for one block section only. It was found particularly in mountainous regions, where the view of the track ahead is obscured, that this was not sufficient, if a reasonable speed was to be maintained. Three general methods have been used to supply the engineman with additional information.

(1) By the overlap, which is an extension of the track circuit one or two thousand feet beyond the advance signal. The effect of this is to encourage an engineman to pass a signal at danger, by giving him the assurance that the track for a considerable distance beyond it is clear. As there is a large element of danger in this, the use of the overlap as outlined is not considered good practice.

(2) By the use of the distant signal which, when clear, indicates that the home or main signal is clear, and when blocked tells the engineman that he must be prepared to stop at the home signal. The distant signal is frequently placed on the same mast with the preceding home signal, and by this means the condition of the track for the two blocks ahead is indicated.

(3) By the use of the three-position signal, which indicates the condition of the track for two blocks ahead as follows:

Blade horizontal, first block occupied.

Blade inclined at an angle of forty-five degrees, first block clear, second block occupied.

Blade vertical, both blocks clear.

Automatic block signals are usually operated on the permissive system as follows: If a signal is in the stop position, the train must come to a full stop for one minute, after which it may enter the block under control prepared to stop in case of danger without any additional signal or warning.

The number and location of automatic block signals varies with the nature of the service. On lines of heavy traffic they must be placed as close together as possible, so as to get the maximum operating capacity out of the line. In no event should they be placed any closer than the distance required by the fastest and heaviest train to come to a full stop.

The automatic block signal is superior as a safety device to any of the manual block systems, because in addition to making known the presence of a train in the block, it also gives an indication of track obstructions, such as cars on sidings fouling the main line, broken rails or other defects destroying the continuity of the track.

The automatic block, like the manual, does not and cannot guard against the failure of the engineman to obey signals. The only manner in which the engineman can be controlled is by some system of automatic speed control or train stop, which would shut off the steam supply and set the brakes on the locomotive. There has been considerable talk about these devices but so far nothing practical for general use has been developed, and we must therefore depend on the care and watchfulness of the man at the throttle. After all, in spite of the multiplicity of automatic devices, we must always in the last analysis depend on a man or men for our safety.

One of the latest developments in automatic block signals is the use of alternating current signals. An installation of this kind was recently completed on the Southern Railroad between Denim, N.C., and Charlotte, N.C., a stretch of 100 miles. The line had been previously operated under the manual block system with 19 stations. When the new system was installed 15 of the 19 operators were no longer needed and were sent to other parts of the line. The power-house was installed at about the middle of the system and the current, which was also used for lighting stations and other buildings along the right-of-way, was transmitted at 4,400 volts. There are 118 signals in the system and the total energy required for the signals, track circuits and lights in the signals, is less than 10 kw.

There are at present more than 35,000 miles of automatic block signals in use on American railroads, and the mileage is rapidly increasing. Their installation in many instances is an economy, because aside from the greater safety secured they increase the traffic-carrying capacity of the line to such an extent that the construction of an additional track, entailing a much larger expense, may frequently be indefinitely postponed.

Interlocking.—This has been defined as "An arrangement of switch, lock and signal appliances so interconnected that their movements must succeed each other in a predetermined order." The term includes the cabin, the machine, switches and signals and all the connections and appurtenances.

Patents for manually operated interlocking devices were first granted in England in the year 1856, and in 1873 the system had been so generally adopted in England that the London & Northwestern Railway alone employed 13,000 interlocking levers. The first experimental interlocking installation was made in the United States at Spuyter Duyvil Junction, New York City, in 1874. The first important installation on a commercial basis was made by the Manhattan elevated lines in New York City in 1877-78.

Interlocking resulted from the desire on the part of English railways to save labor by concentrating in a single frame the levers operating a number of widely separated switches and signals. After this it was a short and simple step to so lock these levers one with the other that a clear signal could not be given unless the route was properly set up, and so that signals for conflicting movements could not be given. As the cost of labor is higher in the United States than in England there was a demand in this country for an interlocking that would permit of the operation of switches and signals over greater distances and with fewer operators. This resulted in the development of a hydro-pneumatic interlocking, which was first installed in 1884 at Bound Brook, N.J., at the crossing of the Philadelphia & Reading and Lehigh Valley Railroads. From 1884 to 1891 eighteen of these plants, having 482 levers, were installed on six railways. As the system developed many serious defects were found, and its inventors devised the electro-pneumatic system in 1891, which is still in general use, particularly in large installations.

The first interlocking in the St. Louis territory was installed in 1883-84 to control switches and signals at both ends of the tunnel, and at about the same time the crossings, switches and signals at the east end of the east approach to the Eads bridge were also interlocked. The levers of these machines were made to operate special valves which controlled the hydraulic pressure used to operate the switches and signals. Pipes were laid from the ports of the valves to the switch and signal-operating mechanism in which the pressure was maintained by a system of pumps and accumulators or hydraulic rams.

It is here noted that this was one of the first interlocking plants using other than manual power installed in this or any other country. This type of machine, although it developed many defects, was continued in service with some modifications until 1899, when the present electro-pneumatic plant was installed at the tunnel entrances.

Interlocking development has easily kept pace with that in other fields.

The principal types of machines now in use in this country are the mechanical, the electro-pneumatic, the pneumatic and the all-electric.

Mechanical.—A mechanical interlocking plant consists of a frame of levers in a tower, which are connected by means of pipe and wire-runs to switches and signals which are moved by manual power applied to the levers in the tower. Where the distances are not too great, the switch layout comparatively simple and traffic light, this type of plant is both cheap and efficient. With the present tendency toward the control of trains by the block system, most modern mechanical plants are equipped with a number of electric safeguards, such as power distant signals, track circuits, electric route locking, etc. These trimmings in some instances have cost more than the mechanical interlocking itself.

Electro-Pneumatic.—Electro-pneumatic interlocking was first placed on the market in 1891 by the Union Switch and Signal Company. It was found to be particularly advantageous for use in large, complicated installations. The original St. Louis Union Station interlocker, built in 1891-92, was one of the first large installations of this system. This was followed a year or two later by the South Boston station interlocker, and since that time the system has been installed in some of the largest plants in the country, including the St. Louis Union Station as remodeled in 1903-1904.

Electro-pneumatic interlocking is described as follows: Compressed air at a pressure of about 85 lbs. is stored in a reservoir at or near the signal tower and is conveyed in pipe laid underground to cylinders, one at each switch and signal, in which the pressure by means of a piston, moves the switch or signal. The admission of air to a cylinder is controlled by an electric magnet fixed at its side, and the circuit of this magnet is controlled by a miniature lever in the cabin, the wires being run from the switch or signal to the cabin. These little levers are suitably interlocked the same as the large levers in a manual machine. The movement of a lever to work a switch does not, however, actuate the interlocking which releases the lever to be moved next; for the lever movement does not insure that the switch has actually been moved, it only closes the circuit. The next lever is held locked until by an electric current, the circuit of which is closed by the switch rails themselves, after their movement is completed, the "indication" of such completion is sent back to the cabin permitting the unlocking of the next lever.

Electro-pneumatic, in common with other forms of power interlocking, has many advantages over mechanical or manual, particularly in large complicated installations in which the installation of manual interlocking is practically impossible on account of the size of machine required and the great number of pipe-runs. The same amount of interlocking can be accomplished by power with fewer levers and each lever occupies about one-third as much space in the machine. A manually operated machine to operate the Union Station layout, if it were possible to properly lock it, would be at least two hundred feet long; and the pipe-runs would be so numerous and bulky that it would be difficult, if not impossible, to find space for them and the tracks too.

Pneumatic.—Another form of machine is the pneumatic or low-pressure air which has been used to a limited extent within the past 12 or 14 years. This machine acts more slowly than the electro-pneumatic or all-electric. In this system the pressure in the cylinders, moving switches and signals is 15 lbs., and in the small pipes leading to the diaphragm valves it is only 7 lbs. per square inch. The signalman's work consists in opening and closing these valves. The interlocking is the same as in other machines.

All-Electric.—The all-electric interlocking was developed by J. D. Taylor about 1900. A switch is moved by a one horse-power electric motor fixed to the ties and worked by an electric current conveyed by wires from a dynamo or storage battery in the cabin; and a signal by a motor of 1/6 horse-power, fixed to the signal post. The storage battery is usually charged by a generator run by a gasoline engine; and the amount of electric power used is so small that a small engine need be run but a few hours daily.

The machine in the cabin consists of a frame supporting horizontal sliding bars or levers, each movement closing a circuit to a switch or signal. The levers are interlocked as in other machines, and as in other power machines the interlocking is controlled by an indication sent to the machine from a switch after it has actually completed its movement. This "indication" current is generated by the momentum of the switch motor, which is converted into a generator for a fraction of a second after it has completed its work of moving the switch. The movement of a switch requires a current of only seven amperes.

All-electric interlocking has been manufactured since its development by the General Railway Signal Company.

Among the large all-electric installations may be mentioned the new Grand Central Terminal at New York, and the Chicago & Northwestern Terminal at Chicago. The latter is one of the most recent and up-to-date installations, so that a short description of it may be interesting. The Lake Street or main plant controls the entrance to 16 station tracks, which converge into six main lines. The semaphore signals are all of the three-position upper quadrant types and the dwarf signals are also three-position. The signal blades when horizontal mean stop; when inclined at an angle of 45°, proceed, stop at next signal; and when vertical, proceed.

In place of mechanical detector bars, which are usually installed at all interlocked switches to prevent the throwing of the switch under a train, electric track circuit locking is substituted. Miniature lights are placed on switch levers to indicate the presence or absence of trains on the switches and illuminated track diagrams are employed to give information to levermen as to occupied or unoccupied condition of all tracks.

An elaborate system of route and release locking is installed at this point, which by means of track circuits, controlling lever locks in the interlocking machine, prevent the movement of switches in a given route after a clear signal has been given to and accepted by a train over such route, even though the governing signal has been restored to normal or stop position. An ingenious feature of this "Route and Release" locking system is that while it is impossible to change the position of switches ahead of a train moving over the route, it is possible to move switches immediately after it has passed, thus permitting a new route to be lined up for a following train. In the older methods of track circuit route locking, the train must pass over all the switches in the circuit before any of them can be moved. The former scheme greatly facilitates train movement, while retaining all of the safety features of the latter.

There has been in late years a good deal of discussion as to the proper signal aspects for both day and night. While practice is not uniform the consensus of opinion is that a semaphore signal at the right side of the track or above it, with the semaphore blade to the right of the mast and working through the upper quadrant is the best practice. In this type of signal the blade horizontal means stop; inclined upward at an angle of 45°, proceed cautiously; and inclined upward at an angle of 90°, proceed.

At night the stop signal is a red light, the caution a yellow and the proceed a green light. Formerly, a white light or an ordinary flame seen through an uncolored lens was the clear indication, but on account of the danger of confusing this light with others in the vicinity, and the fact that the breaking of a red lens might cause a light to appear white when it should be red, the green light was adopted for the clear indication.

At interlocked railroad crossings it is the general practice, and in most States the law requires the installation of derails and distant signals. The derail on high-speed tracks is placed about 500 feet from the crossing and will throw a train off the track if the stop signal is not obeyed by the engineman.

The distant signal is placed about 2,000 feet ahead of the derail and warns the engineman that he is approaching an interlocking plant. The distant signal gives two indications—one that the home signal is clear and that he may proceed over the crossing without stopping, and the other that he must approach the home signal prepared to stop.

It is customary in modern installations to have a track circuit route locking which will prevent the moving of any switch or signal on the route after a train has accepted and passed a clear distant signal and until it has passed the home signal or through the entire plant.

RAILWAY ELECTRIFICATION IN ENGLAND.

A brief description has recently been published on the electrification by the London and North Western Railway Company of some 80 miles of single track, the first section of which was placed in operation on May 1st. of the present year. In all, about 7½ miles of single track have been equipped to date. High tension cables will, as far as possible be carried on short posts along the railway. The low tension cables will be laid underground. The conductor rails are all of a special low carbon soft steel having a weight of 105 lb. per yard; and the electrical resistance is approximately 6½ times that of copper. The rails are supported on porcelain insulators attached to the sleepers by malleable iron clips.

Trains, such as it is proposed to operate on these lines, will consist each of three cars having a total length of 179 feet. End doors are used with through communication, and both cross and longitudinal seats are provided. The electrical control gear will be supplied by the Siemens companies. Every motor car will be fitted with four motors of 250 h.p. each.

The generating equipment will consist of 5 turbo-generators of 5,000 kw. each, three-phase, 11,000 volts, 25-cycles; and transformers and rotary converters will be used to reduce the current to 600 volts d.c. Storage batteries will also be installed for peak and emergency service.

The transformers are being manufactured by the British Electric Transformer Company; sub-station plants, by the British Thompson-Houston Company; and the electrical apparatus of the trains, by the Maschinenfabric Oerlikon. Owing to the war, however, it is almost certain that all contracts with the German company have been cancelled.

The state of Texas mined 2,429,144 short tons of coal in 1913, valued at $4,288,920, according to E. W. Parker, of the United States Geological Survey. This production was nearly evenly divided between lignite and bituminous coal, with the balance slightly in favor of the latter. Both classes of coal showed increases in production in 1913, and both made their record output. The total production in 1913 exceeded that of 1912 by 240,532 short tons, or 11 per cent in quantity, and by $633,176, or 17 per cent., in value.

ECONOMICS OF WATER WASTE IN CITIES.

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A PERUSAL of the technical press and of the papers and discussion at the various conventions of engineers will indicate that the subject of water consumption and waste is one of considerable importance.

That water is being wasted in cities is recognized by engineers, and that it cannot be completely eliminated is admitted by all. But the quantity which is used or wasted in *excess* of allowable or unpreventable waste plus that actually consumed for all legitimate purposes, represents a tangible and potential source of wealth. The means by which such wealth can be conserved is dependent on the method adopted and the manner in which it is organized.

The influences which affect the consumption of water are the nature of the industries, the wealth and habits of the people, the extent to which water is used for fountains or other ornamental objects, watering of lawns, street sprinkling and other public purposes. Climate has also a very considerable influence especially as to the amount used for sprinkling purposes, and that which is wasted in winter to prevent freezing. It is probable, however, that the most important factors in determining the consumption of water is the degree of care taken to detect leakage and other waste, and the fact as to whether the water is sold by measure or otherwise. (1)

It will be assumed that the actual consumption of water on the North American continent is on a more generous scale, and that the climate, as a rule, is less humid and consequently the gardens and streets receive more watering than in Europe. This, however, cannot account for the great difference in the average consumption per capita.

Whilst it is not always a sure method of comparison to consider the consumption in any one city with that of another, owing to the different conditions which obtain, yet when several cities are compared, the above statement loses some of its force.

The following is a list of a few Canadian and American cities selected at random from references in various papers and reports:

City.	U.S. gals. per capita.	Population.	Source of information.
St. John, N.B.	250	42,500	Commission of Conservation
Vancouver, B.C. ...	164	120,000	Commission of Conservation
Halifax, N.S.	260	46,600	Commission of Conservation
Quebec, Que.	161	78,200	Commission of Conservation
Hamilton, Ont.	148	81,000	Commission of Conservation
Ottawa, Ont.	220	87,000	Special Report
Toronto, Ont.	120	450,000	Commission of Conservation
Montreal, Que.	130	555,000	Hering&Fuller Report, 1910
New York City, N.Y.	111	4,800,000	(2)
Buffalo, N.Y.	321	425,000	(2)
Chicago, Ill.	235	2,200,000	(2)
Philadelphia, Pa. ...	203	1,600,000	(2)
Milwaukee, Wis. ...	115	410,000	1913 Report
Kansas City, Mo. ...	126	300,000	1913 Report
Cincinnati, O.	131	392,000	1913 Sewerage Report
Pittsburgh, Pa.	197	550,000	(2)
St. Louis, Mo.	109	687,000	(2)
Cleveland, O.	102	560,000	Toronto 1912 Report
Detroit, Mich.	173	466,000	(2)
Baltimore, Md.	115	560,000	(2)
St. Paul, Minn.	61	210,000	
New Orleans, La. ..	53	370,000	1913 Report
Boston, Mass.	108	733,000	1913 Report
Albany, N.Y.	242	101,000	Engr. Record, Aug. 3, 1912
Salt Lake City, Utah	400	......	Engr. Record, July 25, 1913

The following are the statistics of a few European cities:—

City.	U.S. gals. per capita.	Population.	Source of information.
Vienna, Austria	15	1,800,000	(3)
Aachen, Germany	25	....	(4)
Frankfort-on-Maine, Germany	46	400,000	(5)
Wiesbaden, Germany.	28	100,000	(3)
Hamburg, Germany..	44	757,000	(3)
Munich, Germany ...	45	524,000	(3)
Berlin, Germany	22	2,100,000	(3)
Basel, Switzerland ...	42	....	(4)
Copenhagen, Denmark	27	....	(4)
London, England ...	43	6,721,207	1913-14 Report
Liverpool, England ..	36	960,000	(6)
Newcastle-on-Tyne, England	36	590,000	(6)
Hull, England	49	250,000	(6)
Manchester, England.	42	1,200,000	(6)
Devonport, England..	51	75,000	(6)
Glasgow, Scotland ...	72	1,150,000	(6)
Nuneaton, England ..	21	37,000	(7)
Stirling, Scotland	64	28,000	(7)
Plymouth, England ..	47	152,500	(8)
Sydney, Australia ...	48	668,000	(9)
Riga, Russia	25	....	(4)
Weardale and Consett, England	22	400,000	Letter

Chicago has about the same population as Vienna but the quantity of water consumed is over 15 times as great; Ottawa is about the same size city as Devonport but uses about 4½ times as much water; Montreal and Newcastle-on-Tyne are nearly similar in size but Montreal uses 3½ times the volume of water used in Newcastle; Milwaukee and Frankfort-on-the-Maine have approxi-

(1) Public Water Supplies, Turneaure and Russell, 1903, page 16.
(2) De Varona's paper, American Waterworks Association, 1913.
(3) Lehmann's Hygiene, 1909.
(4) Hütte Engineers' Pocket Book, 1911.
(5) Stadtische Tiefbauwessen, Frankfort, 1903.
(6) American Waterworks Association, proceedings, 1912.
(7) Proceedings, Institution of Municipal and County Engineers, Vol. XXXVIII.
(8) Proceedings, Institution of Municipal and County Engineers, Vol. (XXXVII.)
(9) Proceedings, American Waterworks Association, 1911.

mately the same number of inhabitants, yet the former uses three times the quantity as the latter; Basel in Switzerland and Buffalo in New York State are nearly alike in population, but Basel uses only one-eighth as much water; New York City, the greatest city of the west, requires 2½ times the quantity needed in London, England. The reader who will continue the comparisons will find material for thought and investigation. There are, of course, certain conditions in Europe which tend to keep the consumption low, and these should be studied so as to arrive at a reasonable comparison. Such conditions are the number of faucets fixed on services, types of dwelling, methods of living, density of population in certain quarters and so on, but space will not permit discussing them at present.

In Germany an allowance of 100 litres per capita per day is ordinarily considered as ample for all city uses—this is equal to 27 U.S. gallons. Mr. Edward S. Coles, in a paper read before the American Waterworks Association in 1912, held in Louisville, Kentucky, presented a list of British cities, the average domestic consumption in which was 29.8 U.S. gallons and the average trade consumption was 13.6 gallons, or a total of 43.4 gallons daily per capita.

Even granting that the actual use of water for ablutionary and other purposes is more generous here than in European cities, it is palpable that the excess will not be great.

An American authority (10) estimates that the daily average would be:

For domestic purposes ..	25	gallons per capita
For commercial purposes	20	" " "
For public purposes.....	5	" " "
Loss	20	" " "
Total	75	" " "

There are many cities in the United States and Canada that are thriving on a smaller average. Domestic allowance of 25 gallons daily per capita is more than ample, and when it is borne in mind that a large number of industries, railways, etc., do not use city water, as a perusal of Cincinnati Sewerage and other reports clearly shows, an allowance of 20 gallons per head per day for industrial consumption is high. The loss of 20 gallons is excessive, whilst the preceding allowances evidently include waste also.

The average of the European cities cited is about 40 gallons per head per day. If this figure is increased by 25 per cent. it will represent a reasonable quantity and includes unpreventable waste, which occurs in all cities.

The writer will, for the purposes of this article, assume two hypothetical cities, each of 250,000 inhabitants. One city will consume 50 gallons per capita daily, and the other 150 gallons. Approximate estimates, based on published statements which will be quoted, will be submitted to show the economics of waste. The water is supposed to be filtered, chlorinated and pumped 200 feet high or equivalent in pressure, and distributed. The sewage will be collected on the separate system and treated bacteriologically.

There is ordinarily one ratepaying consumer in every six inhabitants, so that in each city of 250,000 population there will be about 42,000 water consumers.

The daily consumption of water will average: 250,000 × 50 = 12,500,000 gallons; 250,000 × 150 = 37,500,000 gallons, and to these figures must, of course, be added an allowance in capacities of mains, pumps, etc., to meet the fluctuating hourly flows.

(10) Water Supplies, Turneaure and Russell, page 22.

The waterworks of the six largest cities in Wisconsin (11) supplying an average of 81 gallons per head daily, cost about $187.25 per consumer, but eliminating one city, where the cost exceeded the average by nearly 100 per cent., the mean of five cities was $151.42 per consumer. Accepting this as the basis of cost, the waterworks system for a city of 250,000 inhabitants or 42,000 consumers will be about $6,360,000. It is therefore reasonable to estimate that for 50 gallons per head daily the cost will be about $6,000,000 and for 150 gallons per head $7,000,000. The extra $1,000,000 will annually cost 5 per cent. for interest and, say, 2½ per cent. for depreciation, a total of $75,000 per annum.

The cost of pumping water will be about six cents per million foot-gallons (12); so that 12.5 million gallons raised 200 feet will cost about $54,750, whereas 37.5 millions raised to the same height will cost $153,250, an extra cost of $109,500 per annum. The average cost in 21 cities in Wisconsin in 1911 was $16.70 per million gallons pumped and on this basis the annual cost would be $76,000 and $228,000 respectively.

Filtration and sterilization will cost about $3.37 per million gallons (13), to which is added the cost of pumping into filters, making a total of $3.50. So that, in the first city, this work will cost about $16,000 and in the second $48,000, a difference of about $32,000 per year.

The distributing mains, sufficient for domestic, industrial and fire purposes, should satisfy the National Board of Fire Underwriters' (1910) standard and also allow for the usual maximum fluctuations in consumption.

The National Board of Fire Underwriters' general requirements may be expressed by the following equation:

$$Y = 1020 \sqrt{X} (1 - 0.01 \sqrt{X})$$

Y = gallons per minute.

X = population in thousands.

The cities under consideration have about 250 thousands population, so that to satisfy the above requirements

$$Y = 1020 \sqrt{250} (1 - 0.01 \sqrt{250}) = 13,570 \text{ gals. per min.}$$

The consumption of 12,500,000 gallons per day is equal to an average of 8,700 gallons per minute and 37,500,000 gallons daily represents an average of 26,000 gallons per minute, but the maximum rate will probably be about 150 per cent. of the average. Therefore, the relative requirements of the two cities will be as follows:

	No. 1 City.	No. 2 City.
Fire purposes	13,570	13,570
Domestic and industrial purposes.	8,700	26,000
Add 50% for max. hourly demand	4,350	13,000
Total gallons per minute	26,620	52,570

In other words, the capacity of the mains in the city No. 1 will be only one-half of that in No. 2.

According to published statistics (14), distributing mains absorb about 64 per cent. of the total capita expenditure. There are other published figures which conflict with this percentage, but as the above result was evidently obtained by careful analysis of at least 22 dif-

(11) Wisconsin Railroad Commission Report, 1911, page 453.

(12) Wisconsin Railroad Commission Report, 1911, page 453.

(13) Fuller, Baltimore Works, Engineering Record, May 9th, 1914.

(14) Proceedings, American Waterworks Association, 1911, page 75.

ferent city waterworks, it may be taken for granted that it is reliable. The cost of the distributing mains in No. 1 city will therefore be about $3,840,000 and in No. 2 about $4,480,000 and additional expenditure of about $640,000. The cost of operating distribution works may be estimated at $2.50 per million gallons pumped (15) which in the first city would amount to about $11,400 and in the second about $34,200, a difference of $22,800 per annum.

After having distributed the water to the people, the city must also provide sewers to drain it away after use or misuse. The lateral sewers are, of course, designed for flows which normally will only partially fill the pipes. The trunk sewers must be calculated so as to be ample to accommodate the districts served.

Supposing that it was necessary to provide one main conduit to the outfall works, that the grade was 1 in 5,000 and that no ground water was admitted, the diameter of such a sewer to convey 12.5 million gallons per day would have to be about 54 inches and for 37.5 million gallons 82 inches, this does not take into account the hourly fluctuations, otherwise the diameter would have in each case to be larger. Accepting Cincinnati prices (16) the cost of these conduits would be:

54-in. Diameter Sewer—

Trenching 8 yds. @ $1.25	$16.00
Concrete, 1.38 yds. @ $15	20.70
Cost per foot run	$30.70

82-in. Diameter Sewer—

Trenching 11.3 yds. @ $1.25	$13.95
Concrete, 2.24 yds. @ $15	33.60
Cost per foot run	$47.55

That is, to convey three times as much sewage as would be required economically, the ratepayer would have to pay about 60 per cent. more in capital expenditure (and of course in annual taxes for interest and maintenance) on such trunk sewers. When the cost of vitrified pipe sewers are analyzed, it will be found that the extra cost for sewers laid to carry, say, 1,200 gallons per minute and 3,600 gallons per minute will be in the following ratio:

15-inch Pipe, Grade 1/600—

Vitrified pipes	$ .75
Trenching 10 feet deep	.70
Total per foot run	$1.45

24-inch Pipe, Grade 1/800—

Vitrified pipes	$2.00
Trenching 10 feet deep	.70
Total per foot run	$2.70

Extra cost 86 per cent., so that the additional cost to convey three times a given volume of sewage increases as the diameter of the sewers diminishes. The cost of sewering a city is probably about the same as to provide water mains, perhaps more, because water mains operate under pressure and sewers by gravity; the former are always full, whilst the latter are generally only partially full and consequently larger in diameter or dimensions. Many of the lateral sewers could not be reduced in size even if the water consumed was maintained at 50 gallons per capita, but many of the larger sewers could, and the saving in capital expenditure would be tangible.

(15) Wisconsin Railroad Commission Report, 1911, page 445.

(16) Report on a Plan of Sewerage, Cincinnati, 1913, page 252.

The next item of expenditure is for sewage disposal works. Whilst to some degree it is true that an extravagant use of water does not necessarily entail the construction of works to treat sewage, in proportion to the flow or volume, it nevertheless means works of a greater capacity than would be necessary in the case of economical water consumption, for tanks and pumps must be in some relation to the hourly quantity of sewage. The capacity of the pumps (if any) must be more than equal to the maximum hourly flow of sewage, with reserve pumps and power as well, in case of breakdowns or other contingencies, common to such plant. The velocity of the flow of sewage through the tanks must not for long periods exceed a critical limit. To attain this condition it is evident that tanks capable of treating 37.5 million gallons daily will be much larger than would be necessary for a discharge of one-third that volume.

Mr. George H. Wisner, in his report (17) supplies an interesting table of costs which is copied below:

Type of tank.	Nominal period of settling.	Gallons per capita.	Cost per capita.
Emscher	3 hours	200	$1.44
Dortmund	4 hours	200	.84
Straight flow	8 hours	200	.77
Straight flow	6 hours	200	.58

As Emscher or two-story tanks are now prominently before us, its estimated cost per capita will be provisionally accepted. To maintain the same velocity for 150 gallons per capita daily, the cost will be $\$1.44 \times \frac{150}{200} =$ $1.08 and for 50 gallons per day $\$1.44 \times \frac{50}{200} = \$0.36$. The writer does not contend that the cost of these tanks will be in strict proportion to the flow of sewage, as there are items of expenditure which are not proportionate; still, taken as an entity, the cost will not seriously exceed the above. Mr. Clark, when discussing a plant in course of construction in Baltimore, stated that the detention period with Emscher tanks would be two hours (18)—which is the ordinary standard detention period—consequently, to maintain this detention period as closely as possible, the number or sizes of the tanks must, in the cases under present discussion, be approximately in the same ratio as to dimension and cost. But to allow for contingencies, assume that the cost would be $1.10 and 40 cents respectively per capita, then, 250,000 × $1.10 = $275,000, and 250,000 × 40 cents = $100,000, a difference of $175,000 which, at 5 per cent. interest and 2 per cent. maintenance, etc., means $12,250 per annum.

Perco filters, again, are designed to deal with about 2,000,000 gallons per acre daily. Columbus filters were designed for this rating. Mr. George W. Fuller states in his book that his practice has been to specify for average conditions a 6-foot filter at an average rate of two million gallons per acre per day (19). This would be for a sewage flow of separate sewers approximately 100 gallons per capita daily. It is contended that perco filters will deal with approximately the same quantity of organic matter per acre per day, regardless of the degree of dilution. In other words, the organic matter from a residential city will, in the aggregate, roughly amount to the same

(17) Report on Sewage Disposal, Sanitary District of Chicago, 1911.

(18) Engineering Record, July 4th, 1914.

(19) Sewage Disposal, George W. Fuller, 1912, page 697.

quantity whether it is contained in a large or small volume of water. The British Government (Local Government Board) ordinarily requires in the case where there is no land for subsequent treatment or a large river for effective dilution, a filter 6 feet deep and one acre in area for each million gallons of sewage (dry weather flow) but when, as is the practice in America, a river is available for the ultimate oxidation of the filtrate, then the area is about one-half. It is, therefore, reasonable to postulate that for a consumption of 50 gallons per capita daily the area of filter will be about one acre per million gallons and for 150 gallons per day an area of one acre for each two million gallons, on which basis the respective areas will be about 12½ and 18¾ acres. A reserve must be added, say, ten per cent., which will increase the areas to 13.75 and 20.625 acres. Mr. Wisner estimates the cost of perco filters at about $28,000, whilst, according to the experience of other cities the average was about $38,000 (20). Basing the cost at $30,000 per acre, then, the first case will require an expenditure of $412,500 and the second $618,750, a difference of $206,250, which, at 5 per cent. interest, is equivalent to an annual burden of $10,312. The cost of operating and maintaining these filters may be placed at $2 per million gallons (21). This will amount to $12.5 \times 365 \times 2 = \$9,125$ and $37.5 \times 365 \times 2 = \$27,375$.

Sterilization of the filtrate by hypochlorite of lime costs about $1.67 per million gallons treated (22), when 4½ parts of available chlorine per million parts are applied. This for the first case would mean $7,620 and in the second case $22,860.

Summarizing the items already mentioned in the foregoing observations, the following results are obtained:

	No. 1 city. Consumption, 50 gals. per capita daily.	No. 2 city. Consumption, 150 gals. per capita daily.
Interest and depreciation on total capital on waterworks, per annum	$450,000	$525,000
Annual cost of pumping	54,750	153,250
Annual cost of filtration and sterilization	16,000	48,000
Annual cost of distribution works	11,400	34,200
Total on waterworks	$532,150	$760,450
Annual cost of sewers	.....	.....
Annual cost of operating sewage tanks, plus interest	$ 7,000	$ 19,250
Annual cost of operating perco-filters, plus interest	29,750	58,312
Sterilization of filtrate	7,620	22,860
Total	$ 44,370	$100,420

Adding the two expenditures together we arrive at a rough idea of what it means to the ratepayers:

	No. 1 City.	No. 2 City.
Waterworks	$532,150	$760,450
Sewage works	44,370	100,420
Total cost	$576,520	$860,870

The difference of $284,350, capitalized at 5 per cent., will represent a decent sum of $5,687,000.

The writer has advisedly adopted published figures and in doing so has quoted the authorities, but it is manifest that the above estimates serve only as indications, and therefore each city must be considered separately, although the foregoing statistics answer as direction posts to those who will carefully analyze the financial results to be obtained in their own cities. The foregoing will afford sufficiently safe basis to warrant a close scrutiny into the relative cost to the ratepayers of an economical versus an extravagant consumption of water. Furthermore, in those cities where the water supply is controlled by companies, the foregoing observations will suffice to show what waste means to them, and to their customers. The dividend-producing power of any franchise depends on an efficient management and this in its turn means the stoppage of all preventable waste.

(20) and (21) Engineering Record, 22nd August, 1914.

(22) Report on Plan of Sewerage, Cincinnati, 1913, page 567.

CEMENT PRODUCTION IN UNITED STATES, 1913.

A report on the cement output last year in the United States shows an increasing share of the rapidly growing consumption of cement in the United States being supplied by the domestic industry, production having risen from 8,000,000 barrels in 1890 to 93,000,000 in 1913; while imports of cement have fallen from 2,250,000 barrels in 1890 to 95,827 barrels in the fiscal year 1914; which is, with one exception, the lowest total reported in many years. The United States, according to the latest information received by the Bureau of Foreign and Domestic Commerce, Washington, leads the world in the production of cement, its output being approximately four times as much as that of England and nearly three times that of Germany.

The total quantity of Portland, natural, and puzzolan cement produced in the United States last year was the greatest in the history of the cement industry, according to a recent government report. The total amount was 92,949,102 barrels, valued at $93,001,169, compared with 83,351,191 barrels valued at $67,461,513 in 1912.

The total production of Portland cement in 1913, as reported to the Geological Survey, was 92,097,131 barrels, valued at $92,557,617; the production for 1912 was 82,438,096 barrels, valued at $67,016,928.

Of the 113 producing plants in the United States in 1913, 23 were in the State of Pennsylvania, whose output was 28,701,845 barrels of Portland cement, the largest quantity produced by any one state. The second greatest production came from Indiana, with 10,872,574 barrels, and California was third, with 6,159,182 barrels.

The natural cement produced in the United States in 1913 amounted to 744,658 barrels of 265 lbs. each, valued at $345,889, compared with an output of 821,231 barrels, valued at $367,222, in 1912. Puzzolan cement was manufactured in 1913 at three plants in the United States, in Alabama, Ohio, and Pennsylvania. The output of puzzolan and Collos cements in 1913 was 107,313 barrels valued at $97,663, compared with 91,864 barrels, valued at $77,363 in 1912.

The United States has a comparatively small export trade in cement. In 1913 the total quantity exported was only 2,964,358 barrels, most of which was Portland cement, valued at $4,270,666, compared with 4,215,232 barrels, valued at $6,160,341, in 1912.

In 16 years the United States office of public roads constructed 343 object-lesson and experimental roads. The cost has been borne by the localities, and the work of the engineers sent out has proven effective in spreading information. State-aid laws had passed in only 4 states 16 years ago, but 40 states have now adopted the state-aid principle.

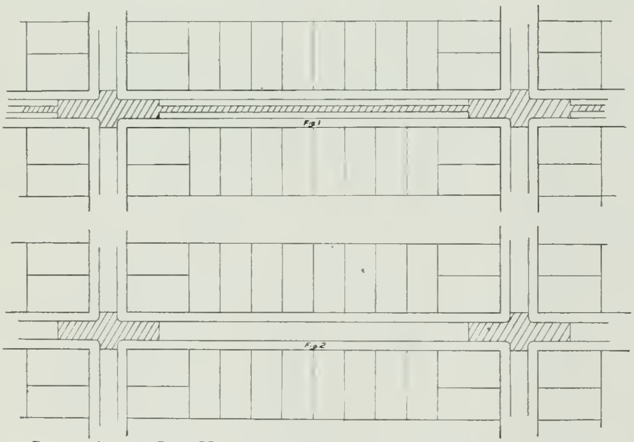
PAVEMENT AND ROADWAY WORK IN OTTAWA, ONTARIO.

By L. McLaren Hunter, A.M.Inst.M.C.E.
City Engineer's Department, Ottawa.

LOCAL Improvement pavements are either petitioned for, by property owners, or initiated under Sec. 9, Chap. 58 of the Municipal Act by the City Council on the advice of the city engineer. If the pavement is petitioned for, the act requires that there must be on the petition the signature of half the property owners representing two-thirds the assessed value of the property—if this is not complied with the petition will be of no use. Supposing, however, the city engineer decides that a pavement on this street is a necessity, then he may advise council to initiate the pavement under Sec. 9. Under these circumstances no petition against the work by the property owners will avail. The work must thereafter be proceeded with.

A Local Improvement report is then prepared by the roadway engineer. This report includes a sketch plan to a scale of 100 ft. = 1 in. showing the location of the work with the lots abutting on it. This L. I. report embraces also the report of the Board of Control and city engineer. The engineer's report contains a detailed statement of the estimated cost of the work.

The cost of the pavements up to July of last year was proportioned as follows: Property owners paid ⅓ the cost of the work opposite their respective lots; the city at large paid the extra third and also all street intersections and the cost of the surface drainage. The city had to pay, also, half the cost of the work opposite any flankage lots, if there were any on the street. It often happened that the city had to pay ¾ the cost of the pavement, so the Council decided to change the by-law and pass another, so that, under the new regulation, the property owners have to pay the cost of all work opposite their property, the city paying the street intersections and half the flankage lots as under the old by-law. Fig. 1 and Fig. 2 show the proportion of costs before and as now regulated. Although pessimists declared at the time the new by-law was passed that it would practically stop all improvements to streets, this happily has not been the case. On the contrary, petitions are now being sent to the city hall in larger numbers than heretofore, and at the time of writing over 200,000 yds. of permanent pavements have been constructed by the council.



Proportion of Cost Under Old (Fig. 1) and New (Fig. 2) By-laws. Shading Denotes Part Payable by City.

When the L.I. report is passed by the board of control and city council, detailed surveys are made and cross-sections taken, by the roadway department. The surveys are plotted to a scale of 40 ft. = 1 in. On the plan a profile of the centre of the road is shown, and also a section

Fig. 3.—Part of Working Profile.

of the type of roadway to be constructed. These are the contract plans, and from them the quantities are calculated for the contractors to tender.

The working profile from which the grades are given is plotted to a horizontal scale of 25 ft. = 1 in. and a vertical scale of 2 ft. = 1 in. The sidewalks on this profile are shown by lines of different colors, and on it are placed the crown of the new roadway in red, and the gutter grades, showing the locations of the various catch-basins and summits. Fig. 3 shows a part of a working profile.

The surface drainage is all done by day labor, and 6 months must elapse after it is completed before the construction of the pavement starts, thus giving time for the loose excavation to become properly consolidated again. At the beginning of the 1913 season the city engineer recommended that all lots not built upon should have sewer services constructed by the city and charged to the owners of the lots along with the first payment on the pavement. The council adopted his recommendation and all the pavements constructed last year had these services put in. In addition to this, all water and gas services are constructed into the building line of the street. This has saved the cutting and disfigurement of the pavements, in more than 50 instances. No more will the city officials have to complain that they are always "digging of it up and putting of it down."

A new system in calling for tenders is being tried this year. Instead of having bulk tenders for each street several streets have been let on the unit principle. A schedule has been added to the specifications upon which the approximate quantities of asphalt, gutter, curb and gutter, etc., etc., have been placed. The contractor fills in his price per sq. yd. or lin. ft., as the case may be, the total charge being placed on a blank form. When the work is finished it is measured by the engineer and charged at the schedule rates. This is the method in practice in Great Britain.

The type of catchbasin and cover used in Ottawa is shown in Fig. 4. It is constructed of concrete with a 6-inch outlet leading to the sewer. The cover is of cast iron and has a very neat appearance on the street.

Asphalt Pavements.—Fig. 5 shows a typical cross-section of an asphalt pavement as it is laid on the resi-

dential streets of Ottawa. There is a 6-inch concrete foundation of a 1:3:6 mixture; ¾ inch of binder, and 2-inch layer of asphalt.

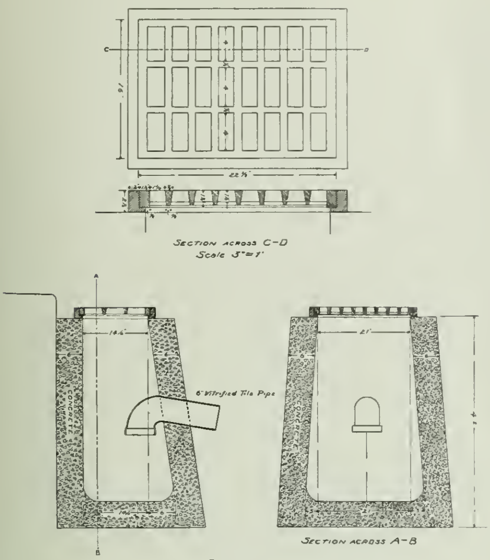


Fig. 4.—Catchbasin Details.

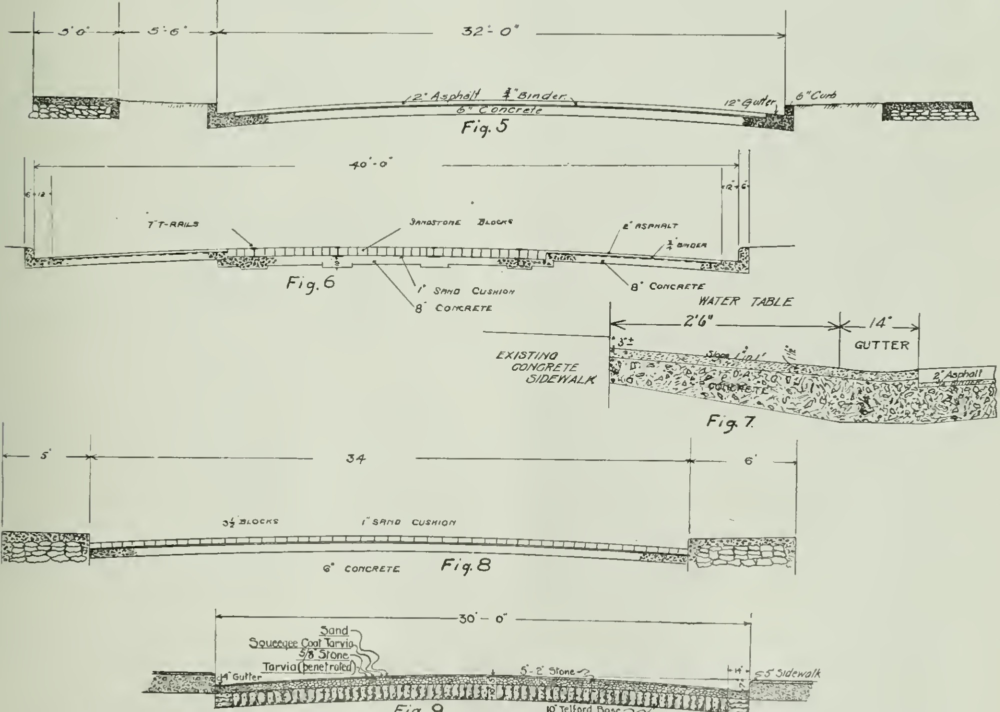
Fig. 6 shows a cross-section of a business thoroughfare, where the street railway operates; 8 inches of concrete is usually laid (especially if there is very heavy traffic) with the same thickness of binder and asphalt. If there happens to be a large number of telegraph poles outside the sidewalk, more so on a business street, a water table is constructed as shown on Fig. 7. This allows an unobstructed run of the water to the catchbasin and also eliminates the necessity for a curb and gutter, which would form a boulevard. In the business section this would be unsightly as the grass between the curb and the sidewalk would be trampled under foot and worn entirely bare.

The asphalts permitted to be used in Ottawa are, Trinidad, Pitch Lake, Bermuda, Mexican, and Californian, and, to show the exact locality from which it comes, the contractors have to furnish the city engineer with proper certificates of shipment.

The matrix or asphaltic cement is made of a mixture of the refined asphalt and flux, proportioned to show the presence of about 22% asphaltine.

The refined asphalt is heated to about 300° F., so that it may be properly agitated by the forced introduction of air. When it is thoroughly melted the flux is introduced and well mixed with the refined asphalt. This is the asphaltic cement that is used for making the binder, and the wearing surface for painting gutters, and, when necessary, for pouring joints.

The wearing surface is formed of the asphaltic cement described above, along with clean gravel and sand or crushed stone. The proportion of each is regulated



Some Typical Cross-sections: Fig. 5, Asphalt; Fig. 6, Asphalt and Stone Block (business street with car tracks); Fig. 7, Detail of Water Table; Fig. 8, Creosoted Wood Block; Fig. 9, Tarvia Macadam Roadway.

according to the kind and shape of the gravel and stone which will pass through a ⅜-inch mesh and be held by a 1-inch mesh. The sand or crushed stone is specified to pass through a ⅛-inch mesh and be held by a 1/50-inch mesh. The stone and sand are heated to about 300° F. by passing through revolving heaters. After all the moisture is driven off and all vegetable matter destroyed, while they are still hot, the asphaltic cement is added.

The proportion of each allowed in Ottawa is as follows (regulated so as to contain from 9% to 11% of bitumen in the wearing surface): Gravel and stone, size ⅜ to ⅛ inch, 25 to 25 parts; sand and stone, size ⅛ to 1/50 inch, 23 to 30 parts; sand, smaller than 1/50 inch, 35 to 35 parts; and asphaltic cement, 17 to 10 parts. These have to be thoroughly mixed and delivered on the work at not less than 250° F.

Two companies operate in the construction of asphalt pavements in Ottawa, namely, The Ottawa Construction Co. (John Foley, managing-director), and the Union Construction Co. (Pat. O'Leary, managing-director).

Creosoted Wood Block Pavements.—About 20,000 yds. of this class of pavement have been laid in Ottawa during the present season, by the Canada Creosoting Co., Toronto. A Norway pine block 3½ inches in depth is being used, laid on a 6-inch concrete foundation, with a 1-inch sand cushion. The blocks are treated with oil to the extent of 16 lbs. to each cu. ft. and are set with the fibre of the wood vertical, in straight parallel courses, at right angles to the curb, except that one row of blocks is placed parallel with the curb, about 1½ to 2 inches therefrom. This is filled with a bituminous filler (two of asphalt to one of pitch). Every 100 ft. a cross expansion joint is made, about 2 inches in width and filled in the same manner as the longitudinal one along the curb. The blocks are laid loosely together on the cushion coat, joints being never more than ⅛ in. in width. After they are laid they are rolled with a light steam roller, until the surface becomes smooth. Then water-washed sand is spread over and allowed to percolate into the joints. This is brushed off after the traffic has been allowed on it for about a week.

The first effect of traffic on the wood block is to broom the edges of the wood slightly, thus closing the joints and making them practically invisible, except near the curb where there is less wear.

Concrete gutters are only laid where the grade of street is less than .5%, otherwise no gutter is used.

Tarvia Macadam Roadways.—This type of roadway is becoming popular in the residential districts of Ottawa. It is laid on a Telford base, being stones about 10 inches thick, laid on edge. On this base is spread a layer of fine stone dust which serves to keep the Tarvia from penetrating into the foundation. The wearing course of evenly crushed 2-inch stone is then spread to a depth of 4 inches and dry rolled. The Tarvia is then spread on, after it has been heated to a temperature of not less than 200° F. Two gal. of Tarvia is used to the sq. yd. in this course. Over it is spread a coat of ⅝-inch stone which is rolled well in to fill up and cover any vein in the surface. A squeegee coat is then applied, about ½ gal. to the sq. yd. being used. Then clean sharp sand is spread on top and well rolled until thoroughly compacted.

Each year these roads are recoated with a coating of Tarvia "B," which adds greatly to the life of the road and also keeps down the dust. Fig. 9 shows a section of Tarvia macadam roadway as laid down in Ottawa.

DISTRIBUTION OF COST OF CONCRETE ROAD CONSTRUCTION.

Some interesting diagrams showing the relative costs of different items entering into the construction of concrete roads is printed in the report of Committee 12 on "The Cost of Constructing Concrete Roads," printed in the proceedings of the National Conference on Concrete Road Building, which has recently been issued.

Three diagrams showing actual costs are reproduced. The first shows the distribution of cost on seven Michigan roads, built 1909-1912, taken from a report by State Highway Commissioner Frank F. Rogers; the second shows similar data on eight sections of concrete road in Wayne County, Mich., built 1912-1913; and the third shows similar data for construction in 1903 reported by the Illinois Highway Commission. The accompanying table shows the percentages of the total for each of the several items in the three cases.

Table Showing Distribution of Cost in Concrete Road Construction—in Percentages.

Item.	Seven Michigan roads.	Eight Wayne Co. (Mich.) roads.	Illinois roads.
Labor:			
Mixing and placing	....	....	11.6
Unloading and laying ..	....	....	13.1
Shaping roadbed and trimming shoulders ..	....	....	6.8
Superintendence and miscellaneous labor	....	....	7.0
Total	43.0	46.0	38.5
Materials:			
Aggregate	29.0	27.0	25.2
Cement	22.7	19.9	31.7
Miscellaneous supplies..	5.3	7.1	2.3
Expansion joints	....	....	2.3
Total	57.0	54.0	61.5

In addition to these three diagrams, another is presented which is designated as a "weighted mean," covering data shown on the other three diagrams. On this diagram labor is given as 44.3 per cent. of the total and material as 55.7 per cent. The item of material is made up of aggregate 27.7 per cent., cement 21.6 per cent., and expansion joints and miscellaneous supplies 6.4 per cent.

Kaministiquia Power Company, which is so closely associated with the upbuilding of the twin cities of Fort William and Port Arthur, Ontario, continues to report good earnings. The net income for June was $22,697. After all fixed charges the surplus amounted to $15,042 for the month. For eight months the company's net earnings total $185,295 and the surplus for the same period amounts to $126,479.

The sources, respective quantities and percentages of the world's production of crude petroleum are shown in the following table:—

Country:	1912, short tons.	Percentage of total.
United States	32,897,060	62.16
Russia	10,174,560	19.23
Mexico	2,910,000	5.50
Roumania	1,987,360	3.76
Dutch East Indies	1,672,000	3.16
Galicia	1,298,620	2.45
India	1,101,450	2.08
Canada	38,750	0.073
Other countries	841,250	1.59

GENERAL CONSIDERATIONS AND COSTS OF REINFORCED CONCRETE DOCKS.

FOLLOWING up the articles that have recently appeared in these columns relating to the application of reinforced concrete in the construction of docks, the available data respecting cost of construction are such that full confidence cannot be placed in them owing to a certain danger of unreliability. Some figures are presented herewith, however, that cover the cost of docks as outlined in articles appearing in *The Canadian Engineer* for August 27th and October 1st, 1914. The data in Table I. have been collected from various publications by Harrison S. Taft and presented in his paper on the subject read before the American Society of Civil Engineers on May 20, 1914. The table gives the cost per square foot of construction.

Maintenance Cost.—A few figures covering the cost of maintenance of reinforced concrete docks in England are noted. In addition to what has already been said on the maintenance question,* the cold storage wharf at Southampton is reported to have cost nothing to date for maintenance. On the other hand, the widened dock and the coal jetties are said to have shown considerable deterioration due to rusting of the steel, it having been improperly placed in these structures. It has been stated authoritatively that "while six to seven years is perhaps a rather short time in which to form any definite conclusions, the maintenance cost (of the above described Port Talbot docks) has been practically nothing"

The annual repair charges on the Purfleet coaling jetty (exclusive of the damage done at the time of the collision) for the first 9 years of its existence are stated to have been but $50 per annum, which, based on its cost, $60,000, is less than one-tenth of 1 per cent.

Table II., from data published by the Chief Engineer of the Mersey Dock and Harbor Board in 1910, gives some very interesting results as respects the cost of annual repairs to six of the reinforced concrete docks at Southampton.

*See *The Canadian Engineer* Aug. 27, 1914.

If the results in Table II. are true, it is no wonder that the English engineers report that their reinforced concrete docks cost nothing for annual repairs.

General Considerations.

Opinions of Foreign Experts.—Although failures have accompanied the use of concrete in sea water and in the construction of reinforced concrete docks, it must be admitted that, if the Engineering Profession did not meet with a failure now and then, it would never acquire anything new, as it is through failures that it gains the most vital knowledge of engineering.

(*a*) In discussing the question of concrete docks, a prominent New York engineer has stated that, of the large number of concrete docks which have come under his observation, the majority have been a success, though here and there he reports a failure due to poor construction and material, and not to defects in the design. It is authentically stated that the reinforced concrete docks at Southampton have shown no deterioration due to salt water action, except at the Southampton coal jetty. The engineers of the Liverpool Docks have been using concrete in connection with their work since 1872, apparently with great success. It has been stated on the best authority that in England the alternation of "dryness and wetness and fluctuations in temperature" does not appear to have affected reinforced concrete sea water structures adversely.

Mr. Henry Hunter, Chief Engineer of the Manchester Canal, England, states that "the concrete in the concrete lock built at Eastham is in better condition at the present date than the day it was deposited," and adds that, covering an experience of more than 30 years of placing concrete in salt water, he has known no failures in such work where the concrete has been properly mixed and deposited.

In discussing the concrete docks of the Port Talbot Dock Company, Mr. William Cleaver has stated that:

"While reinforced concrete requires extreme care, both in the choice of material and in the supervision of the workmanship, the results justify the extensive adoption of the material for dock work."

Table I.—Cost of Concrete Docks.

Location.	Type.	Cost per square foot.
Pier No. 8, Puget Sound Navy Yard	Concrete columns Steel deck-beams. Concrete deck-slab.	$3.11
Naval Station, Philippines	Concrete columns. Steel deck-beams. Concrete deck-slab.	2.60
Balboa, Panama Canal	Concrete columns. Concrete beams. Concrete deck-slab.	3.28
Oakland, Cal.	Concrete piles. Concrete beams. Concrete deck-slab.	3.27
Brunswick, Ga.	Concrete piles. Wooden deck system.	1.40
Charleston Navy Yard, S.C.	Concrete piles. Wooden decking.	2.60
United Fruit Company, Panama	Concrete-protected wooden piles. Concrete deck-beams. Concrete slab.	2.13
Brooklyn, average of two docks	Wooden piles. Wooden caps. Concrete deck-slab.	0.90

The exceptionally experienced dock engineer, Mr. Francis E. Wentworth-Shields, of the London and South-western Railway Company, has stated that "if great care is exercised in making and placing concrete, an impermeable material will be obtained which can withstand the action of salt water." Mr. Shields has also said, "while many engineers were nervous about the life of reinforced concrete (for sea structures), he had observed that maintenance engineers were not so nervous as construction engineers." He is inclined to feel that there is nothing special to be feared respecting the life of reinforced concrete when used in marine work. Although, under certain circumstances, it is likely to deteriorate, he does not think it will do so from simply standing in sea water. He says that though in some cases deterioration has taken place at Southampton above low water, it has not done so below low water; that a 10-year-old reinforced concrete structure standing in sea water at Southampton is in perfect condition at the present date; and that, during the whole experience at Southampton, sea water does not seem to have produced any chemical or other deleterious action on the concrete.

Experiments by Mr. Baldwin-Weisman, in 1907, in England, on the permeability of concrete, show that, if it is well made, it is one of the most water-tight materials known, and that it rapidly becomes less and less porous when water is forced through it.

Mr. V. De Blocq von Keuffeler, in summing up the experience in using concrete for salt water structures in Holland, says:

"A suitable mixture, very carefully manufactured, the use of a good brand of cement with trass, and setting in a moist atmosphere, are the most efficient means of ensuring the preservation of reinforced concrete in sea water."

Mr. I. Ho, one of Japan's expert harbor engineers, who used more than 1,200 mass-concrete blocks in one instance, none of which during a period of 10 years has shown the slightest signs of failure, states, "that whereas a good and proper cement is of consideration, the most important factor is the mode of fabrication."

In reviewing the successful experiences of some of England's leading authorities, the question of the chemical composition of the cement used does not appear to be given. Such information would be of great value, in order that engineers may know whether they use a cement especially manufactured for sea water concrete or simply the ordinary Portland cement, with or without puzzolana, trass, etc.

(*b*) In discussing the deterioration of steel in reinforced concrete, by the action of sea water on ferro-concrete, provided the latter is properly made, Mr. C. S. Meiks, a prominent concrete engineer of England, says that such deterioration "is a negligible quantity." In support of this contention he cites the experience at Southampton, stating "that the exposed steelwork on a pile end that had been in the sea for 8 years was much corroded," whereas the bars in the body of the concrete, on being cut open, were found to be quite free from any rust and as fresh as the day they were put into the pile.

In connection with the building of some of the earlier concrete dock structures at Southampton, it appears that parts or the whole of piles not used were allowed to remain on the beach or shore, exposed to sea water, for some 7 years. At the end of this period the exposed steel had been badly rusted and deteriorated, whereas the part which was embedded in concrete was found to be in fine condition, practically as good as the day it was placed in the concrete. Still, concrete piles lying on the beach are not in the same position as concrete piles subjected to shocks in a dock.

Though the first jetties, built 11 years ago in Southampton water, are in excellent condition at present, the steel in another jetty at the same location has deteriorated, due to electrolytic action.

It is generally accepted by all English authorities that no deterioration takes place in steel when well embedded in the concrete.

(*c*) In speaking of reinforced concrete when used in marine work, Mr. Wentworth-Shields says "it will stand a wonderful amount of shock, and bending due to shocks, if a wooden fender is interposed." At a more recent date, Mr. Shields remarked: "On the other hand, reinforced concrete would not bear being knocked about by heavy ships, and where a structure was subjected to severe blows of that sort it was not easy to find anything better than timber, * * * but, when used at the right time and in the right place, reinforced concrete was a valuable material to dock engineers." From the leading position Mr. Shields occupies among the dock engineers of England, it would be of interest to know just what distinction there is between "a wonderful amount of shock" and "subjected to severe blows."

As an axiom: whatever system or design is adopted for a reinforced concrete dock, in no manner whatsoever should a vessel be allowed to rub against the main piling of the dock. The dock should always be protected by a system of fender-piles.

(*d*) As respects the resistance of a concrete pier or dock, when under such treatment as the Purfleet pier was at the time it was rammed, in 1904, Mr. Meiks, engineer in charge of its construction, states that "the vibration

Table II.—Annual Repairs, Southampton Docks.

Dock.	Erected.	Cost.	Cost of repairs to date.	Average per year.	Annual percentage based on original cost.	Remarks.
A	1899-1900	$24,000	$800	$80	0.0033	Deck for Cattle Wharf, Prince's Jetty (wood piles).
B	1904-06	63,500	375	75	0.0012	Floor or deck on Hennebique piles, Prince's Dock, West Quay.
C	1900	13,800	80	8	0.0005	Floor for wharf, Coburg Quay.
D	1901	3,700	25	3	0.0008	Floor for wharf, etc., Brunswick Half Tide Dock.
E	1908	17,500	....	...	......	Floor for wharf, etc., North Quay, Brocklebank Dock.
F	1908	163,500	....	...	......	Treble-story shed, South Quay, Sandon Dock.

Dock *A*. Subject to the effect of moist air arising from water below it.
Dock *B*. Subject to effect of moist air. Piles more or less submerged, according to water level.
Dock *C*. Complete reinforced shed and pile foundation; not sufficient time to form any conclusion.

was so great at the time of the collision that they thought the entire pier would collapse, but that its elasticity was most satisfactory, due no doubt to its horizontal concrete decking." Mr. Meiks also says that the vibration of a concrete pier supported on piles is nearly as great as in a pier made of timber piling; but this has no particular effect on the structure, judging by the experience gained with the Purfleet pier at the time it was rammed.

In speaking of the Port Talbot docks, Mr. A. E. Carey has stated:

"If the structure (reinforced concrete dock) was properly designed and built, its stability and life were assured, the only serious drawback being the difficulty of repairing damage due to collision."

But how often do collisions happen?

The Chief Engineer of the Port of London, Mr. Bryson Cunningham, recently stated that the art of building reinforced concrete docks in England has attained a degree of perfection greatly in advance of early experimental work. If their early experimental docks are still doing good service, will not their more recent docks become structures of an engineering and commercial success, thus justifying the American engineer in recommending concrete docks as long as they are built in a manner to guarantee impermeability and non-deterioration of the concrete?

Concrete Breakwaters.—As the application of reinforced concrete to dock construction has been developed almost entirely since 1900, some of the most conservative engineers may not feel that sufficient time has elapsed to judge correctly as to the merits of using cement and placing concrete structures in sea water, and as to the advisability of adopting reinforced concrete as a coming type of dock structure. As respects the first point, the prolonged and successful use of mass concrete by foreign countries in breakwater, tidal, and graving dock work would in itself appear to be sufficient answer to all such skepticism.

Though an extensive treatise might be written on concrete breakwaters and their construction, including shore protection, those phases of the use of concrete in sea water are supplementary to the principal subject of this paper. There is apparently hardly a leading seaport or a maritime nation outside of the United States that has not made a wide, extensive and successful use of mass and reinforced concrete in the development of harbor and shipping facilities.

Surprising as it may seem, a number of large concrete breakwaters have been in existence in Japan for more than 18 years. As a matter of fact, the use of concrete in the harbor work of Japan is far in advance of American practice, being apparently on the same high level as in England and other European countries.

Mass concrete has been used very extensively in Belgium and Holland for sea water structures for years, and has given the best of results. In fact, some of the concrete sea walls in the latter country, built in 1867-77 and earlier, are so old as to be called ancient, and have as yet shown no signs of being affected by the action of sea water. Perhaps such a statement needs to be qualified, because some of the principal harbors of Holland are some distance from the sea, and are in fresh or brackish water.

Concrete was used by the Romans and Carthagenians in ancient times. Though it fell into disuse for many centuries, it came into use again in 1840-50. To this day, sea walls built of puzzolana and lime cement by the Romans are in existence in Italy.

The Italian engineers report that Portland cement concrete with an addition of one-eighth to one-tenth by volume of puzzolana gave no signs of disintegration in salt water, even after an exposure of 30 years in the harbors of Genoa, Civita Vecchia, Naples, etc.

At several places on the Italian coast concrete-faced breakwaters have been in existence since 1880, in most exposed positions, costing but little for repairs and maintenance, though subject to the high seas and heavy blows of the Mediterranean.

English engineers were using mass concrete in their tide locks and in the construction of massive breakwaters along the coast of England as far back as 1871, if not earlier. The fact that they have continued to use it more extensively each year, even to building vast reinforced concrete structures standing in sea water during the past 15 years, would appear, in spite of some failures, to be sufficient answer to any doubts the American engineer may entertain on the subject.

At Colombo, India, a concrete breakwater, finished in 1885, showed no failures above or below water at the end of 22 years. As stated above, some of the massive concrete breakwaters of the world have a hard stone facing, or are built of concrete blocks, with or without a stone facing.

The reasons that enable the foreign engineers to accomplish such lasting results with concrete is no doubt due to the fact that they, together with the foreign chemists and cement manufacturers, long ago learned the secret and acquired the art of manufacturing and using concrete in sea water structures. Though the American engineer excels the foreign engineer in certain lines of his profession, it must be admitted that, so far as using cement, and hence concrete, in sea water structures, the engineers of the leading European countries and of certain parts of South America are many years in advance. The American cement manufacturer, the chemist, and the harbor development engineer cannot long remain in such a position without reflecting on their ability as experts in their respective lines of work in the minds of their foreign contemporaries.

In view of the marked success obtained by foreign engineers in the use of concrete for sea water structures, when the execution of such undertakings has been placed in the hands of intelligent, skilful, and experienced men, the American engineer who denies the possibility of making a successful use of concrete for structures standing in sea water puts himself in a questionable position. He thereby confesses either his lack of a world-wide knowledge on the subject, or his inability to carry out properly such classes of construction work to the same successful conclusions as his foreign contemporaries have been doing for years past. Such a confession would seem to indicate a lack of foresight and ultra-conservatism as respects the use of cement subject to sea water conditions, on the part of the American cement manufacturer, chemist, and concrete engineer.

The American engineer who assumes a skeptical attitude toward the practicability and commercial success of reinforced concrete docks has standing before him as silent testimony of their worth and practicability such a vast number of foreign reinforced concrete docks—several about 20 years old and yet in excellent condition, with still more massive structures being built each year, some of them costing less than wooden docks, if reports are true, and most of them saving their owners large sums annually on account of their low cost of maintenance and repairs, with no rebuilding, as with our 15-year creosoted

wooden pile docks—that the grounds on which he stands become somewhat untenable. It is true that all American cements are not as yet wholly suitable for sea water purposes, and perhaps equally true that each and every American concrete engineer has not hitherto insisted on the proper placing of concrete in salt water structures, not fully realizing the importance of the fundamental principles of the use of concrete in sea water, due to the hitherto limited call for such types of structures in America, lumber having been so plentiful and cheap.

Though reinforced concrete docks have been in existence for more than 15 years, and operated successfully, the same old theorems are still put forth in opposition to them and to the practical experience gained during this period. Possibly these same theories will continue to be advanced against the use of concrete in dock work and other sea structures by the most conservative of our leading engineers, though others, guided and profiting by the experience already gained in such uses of concrete, will continue to expend large sums of money in the further development of such structures.

From a prolonged study of reinforced concrete dock construction, as carried out in foreign countries, it would appear that, in spite of early doubts and skepticism, the success in the use of reinforced concrete in dock work obtained by foreign engineers has swept away all such doubts and skepticism. If these are not facts, why are foreign countries and certain ports in America, including the United States Government, expending vast sums of money in building reinforced concrete docks and in other uses of concrete in harbor development and sea protection work; all "in spite of prejudices which leading engineers (psychologically) have against any new type of construction?"

Although the average American contractor may look upon concrete as just so much cement, sand, and stone, or gravel, to be thrown together and dumped into the forms in the quickest possible time, without any regard for the fundamental principles underlying reinforced concrete construction, a commercial proposition purely, such an application of reinforced concrete to dock work will most certainly spell disaster long before the structure is completed.

In spite of its apparent simplicity on dry land, the use of reinforced concrete in dock work calls for more than mere brawn and muscle. It is a class of construction work especially adapted to the broad knowledge, experience, and deep study of the trained engineer in association with an organization well skilled in the handling of concrete in sea water structures—"a field of engineering in which reinforced concrete will prove to be the most permanent and economical, as it has in the building of bridges, etc."

ST. JOHN VALLEY RAILWAY NEARING COMPLETION.

Before the end of the present month the St. John and Quebec Railway Company expect to have the St. John Valley Railway from Gagetown to Centreville, N.B., ready to be taken over by the Intercolonial. Arrangements are being made for the construction of a connecting link from this line to Fredericton. The proposed route through the city was recently laid before the city council by Mr. S. B. Wass, chief engineer of the St. John and Quebec Railway, and who is in charge of the work. Surveys have been under way for a short time past. The city council has just approved of the contemplated route.

CANADIAN MANUFACTURE OF SHRAPNEL SHELLS.

The Canadian Engineer is informed by Colonel A. Bertram that contracts are being let to various manufacturers in Canada to supply 15 and 18-lb. shrapnel shells and component parts for same. Subsequent inquiries by *The Canadian Engineer* show that these orders are being very widely placed. Among the companies which have received them are the Canadian Locomotive Company, the Canada Foundry Company, the Nova Scotia Steel Company, the Canada Forge Company, and the Canadian Billings and Spencer, Limited. The latter are subsidiaries of the Canada Foundries and Forgings, Limited.

The orders are generally for large quantities and will keep various departments of the companies in full operation during the winter.

Mr. T. J. Dillon, president of the Canada Forge Company, Limited, Welland, states that the shells are forged under their new modern hydraulic forging presses, which are equal in power and efficiency to any on this continent or in Europe.

These two plants are fully equipped to produce any size or class of shells or projectiles which may at any time be required by the government Militia or Navy Department, and it is at the Canadian Billings and Spencer Plant where all the forged steel parts for the Ross rifles are made.

To handle these orders on behalf of the Dominion government, acting for the Imperial government, a shell committee has been appointed with headquarters in Montreal. The members of the committee are: Col. A. Bertram, chairman; Thomas Cantley, George W. Watts, E. Carnegie, Col. T. Benson, Lieut.-Col. F. D. Lafferty, and Lieut.-Col. G. Harston.

INVESTIGATION INTO THE IRON MINING INDUSTRY.

Pursuant to a request made to the Dominion government for the granting of some measure of assistance toward the development of iron ore mining in Canada, and in accordance with the statement of the Hon. Minister of Finance in his budget speech during the 1913-14 session of Parliament, that the iron mining industry would be investigated, a committee has been appointed to enquire into the situation and to report the facts to the government. This committee consists of Messrs. O. E. LeRoy, G. C. Mackenzie, E. Lindeman and John McLeish, secretary.

Every owner or operator of an iron ore property in Canada should be interested in facilitating this enquiry and should communicate with the Deputy Minister of Mines at Ottawa, or the secretary of the committee, who will furnish a schedule of questions covering the information required by the committee.

OUR PUMP IMPORTS.

According to a pamphlet recently issued by the Commercial Intelligence Branch of the Board of Trade of Great Britain, the German trade in hand pumps with Canada, prior to the outbreak of the war, was more than 8 times that of Great Britain. That of the United States with Canada was over 51 times that of Great Britain.

Editorial

USE OF CANADIAN-MADE GOODS.

A recapitulation of Canada's import trade shows that during the fiscal year ended March 31st, 1914, we paid $14,686,069 to Germany, $1,787,473 to Austria, and $601,855,332 to other countries, for their products.

A few weeks ago the Council of the Toronto Board of Trade adopted the following resolution with reference to the use of Canadian-made goods by governments, municipalities, architects and engineers in all works under their control:

"Resolved that, in view of the state of unemployment existing, and of the large importation of goods into Canada, much of which could be supplied by Canadian manufacturers, the Council of the Board of Trade of the City of Toronto make representations to the Ontario Government, the City Council, the University of Toronto, the Board of Education, and the societies of engineers and architects, requesting them, where possible, to use Canadian-made goods for all works under their control."

Copies of the resolution were forwarded to the Boards of Trade throughout Canada asking them also to take similar action with governmental and municipal authorities, architects and engineers in their districts.

Realizing that the Trades and Labor Council's estimate of 20,000 unemployed in Toronto at the present time bespeaks similar conditions of a more or less acute nature in other cities, an effort at the development of every possible Canadian resource would undoubtedly result in the employment of the majority of these unfortunate laborers, the building up of Canada's revenue, and the strengthening of her credit as well.

It must not be forgotten that the incoming flood of foreign-made goods has been checked by the manufacturers themselves owing to lack of assurance of early payment, as much as by the consumers who have been obliged to bear the brunt of the financial stringency. The demands for manufactured goods have fallen off, not from a declining desire on the part of the municipalities, etc., to go ahead with their work but from a necessity owing to the unavailability of foreign capital. Under these circumstances the manufacturers of foreign-made goods should feel it no reflection upon themselves or their products that a widespread movement is under way in the Dominion to bring prosperity out of depression by the advocation of home-made goods for every possible service. There are many important works, small and large, that cannot be delayed for a lengthy period. Among them are certain works that demand goods impossible of adequate and successful manufacture, commercially, in Canada. For these we must look to our close friends and neighbors, the United States and Great Britain, who can supply practically every need of this nature.

The Toronto Board of Trade suggests that every manufacturer and merchant lay down the policy for his purchasing department of demanding Canadian-made products; that architects, builders, and contractors keep thousands of Canadian workmen employed by calling for Canadian-made materials in their building specifications; that government and municipal authorities have it in their hands to create a tremendous volume of business in Canadian factories, and that it would be wise for them, as well as patriotic, to give our own workmen the employment so that they will not become a charge upon the country.

THE CANADIAN MUNICIPALITY AND THE BANK.

A letter comes from a reader of *The Canadian Engineer* stating that a certain municipal contract had not been awarded "owing to concerted actions of the Canadian banks." Our correspondent adds that "towns and cities urgently require public improvements and are willing to pay for them in the only possible way of a new country," and hints that "the bankers are taking advantage of the war to squeeze the municipalities."

This view, we think, is held by many people in Canada, but when the position is closely analyzed it is found to be scarcely the correct one. The Dominion is a heavy borrower and to date has obtained £500,000,000, or about $2,500,000,000 of capital from Great Britain. This has been used largely in constructive work, such as the building of railroads, steam and electric; power developments; water and sewerage systems, and various other improvements of public utility or industrial nature. The country was building not only for the present but also for the future. Looking back now, we realize what a tremendous amount of construction work has been done in the past few years.

Dr. Adam Shortt, discussing the situation in a public address at Toronto the other day, stated that, generally speaking, we have in Canada enough constructive machinery and that what is necessary now is more production from the plant which has been installed. This is largely true. Our development has been very rapid and practically all upon British and foreign capital. The supply of capital is now stopped on account of the war. We cannot ask the Canadian banks to take its place. That is not their function, besides which it would be bad business for national credit. A curtailment of expenditure was due anyway, as the country had come to the end of an unusually active period of construction, and the beginning of a period of what it is hoped will be heavy production. The transition of the one to the other is involving some hardships. It means the transfer of labor to some extent, of economy in expenditures and of efforts to direct capital into some new and productive channel. The municipality to-day is trying to do what the individual and governments must do—economize to a reasonable and necessary extent.

The banks' chief duty is to see that they are prepared against all contingencies. Discussing the position of the banks in the present crisis, Dr. Shortt referred to the popular cry in certain quarters for them to come to the rescue just now and provide money to maintain the city and railway construction which had been going on and had been supported by British capital. "That would be perverting the function of the banks," said he, "which was simply the facilitating of exchange. You cannot," he continued, "by adjusting the banking system create one more mouthful of food. The money-lenders abroad must be paid by bills of exchange or counter goods, and not by Dominion notes."

Mr. J. W. Flavelle in a recent public speech said: "Let us bear in mind this is not the banks' trouble. A great number of us seem to have the impression that the only reason that we are unable to borrow all the money we need is because the banks are unreasonable and won't lend it. After all, the amount of resources which we have liquid in this country is comparatively limited. What do our friends the bankers have to do? They are trustees to hold these liquid resources of this country available for the need of this country, distributing them as best they may over the largest surface possible to accomplish the best result."

The same point was made in an interview recently given by Mr. G. B. Schofield, general manager of the Standard Bank of Canada. After stating that the Canadian banks would still stand in most intimate relationship with the manufacturing, agricultural and commercial life of Canada, he added: "Now, the role so long played cannot be cast aside, even if the banks wished to do so; which, as I need not say, they have no desire to do. At the same time, the banks must of necessity be very careful what they do with the people's deposits at this trying time. We must, above all, see to it that we keep our assets liquid. While every aid will be given to legitimate business enterprise, we must be doubly careful to see that such funds as are advanced are not placed in fixed capital forms. Now, as never before, it is necessary to keep our resources in a fluid form."

The Canadian banks have on loan to municipalities throughout Canada at the present time more than $40,000,000. Since 1905, Canadian municipalities have borrowed over $200,000,000, while they have raised also large sums in Canada and the United States. It is not contended that municipal development has ceased in this country, but owing to the economic depression and the advent of the war, much of that development is suspended temporarily.

At the same time *The Canadian Engineer* reiterates its opinion that governments, federal, provincial and municipal in times of extreme trade depression, should spend money on public work so far as proper economy dictates. So long as there is a sound method of financing such works, the banks will probably be found willing to take the necessary action. In a time such as the present, and in view of the fact that the theatre of war is not actually on Canadian soil, the Dominion Government well might employ fairly substantial sums upon certain public works, consistent with economy. Private borrowers will hesitate considerably at present because Canada's chief lender (Great Britain) has a bigger job on hand now than loaning money to its overseas dominions. Indeed, private borrowers, in which are included corporations, are almost helpless, except for funds in hand and for the possibility of borrowing elsewhere than in Great Britain.

It is reported that timber limits extending over 115 square miles along the foreshore of Seymour Inlet and adjacent waters in British Columbia, including 3,000,000,000 feet of high-grade cedar, were recently transferred to a syndicate of capitalists from the United States. It is said to be the intention of the purchasers to begin logging operations on the limits in the near future, and the plans contemplate placing several sawmills on the property. The scarcity of cedar and the increasing price of high-grade timber in the United States have caused American millmen to turn their attention to British Columbia, which has the largest compact area of merchantable timber on the continent. The abolition of the duty on Canadian shingles and other forest products has encouraged and given impetus to the shingle industry, which has made great progress in the province recently.

DEEPENING OF BURNETTE RIVER, B.C.

A very interesting drainage project is being carried out by the Vancouver and Districts Joint Sewerage and Drainage Board. The Burnette River is being deepened between Burnaby Lake and the eastern boundary of the municipality of that name. The new channel will regulate the size of Burnaby Lake. It forms a part of the sewerage scheme reported upon by Mr. R. S. Lee, consulting engineer, Montreal, and adopted by the municipalities. The scheme divides the Burrard Peninsula into several areas according to the bodies of water into which each drains. One of these is the watershed emptying into Burnaby Lake. The report, taking cognizance of the fact that the lake could hold a very limited amount of domestic sewage, but almost unlimited natural drainage, provided that an intercepting sewer be ultimately built around the south shore of the lake; but that for the present, and until the district had become more densely populated (the domestic sewage now being almost negligible), surface water might be allowed to flow into the lake.

The rise in the lake each spring is considerable, owing to the nature of the country surrounding it and also to a ledge of rock at the outlet into Burnette River which prevents more than a certain flow. The lake is thereby rendered more or less stagnant. The Joint Sewerage Commission, therefore, started during the summer on the task of deepening the river. A mile or more at the eastern end of the municipality has been dredged and cleared of boulders and logs which impeded the stream flow. Further up the stream the rock bed has been blasted out to a uniform depth of 6 or 7 ft. lower than the original depth. This cut, about 7 ft. in width and a mile or more in length, conforms to the old bed of the river. A temporary diverting flume is used to deviate the stream from the site of operations.

The Sewerage Board expects to continue the work well into the coming winter. This will necessitate a different method of flow control. It is proposed to dam back the flow a short distance from the outlet of the lake and to curtail it during the 8 hours of each working day, allowing the accumulated water to run off during the intervening 16 hours.

The work will result in a uniform depth, during summer and winter, of Burnaby Lake. It will greatly facilitate the drainage scheme and will permit the reclamation of a considerable area previously subject to floods in the rainy season. Eventually the level of the lake will be lowered several feet and approximately 150 acres more land will be thereby reclaimed. The Provincial Government has been approached with a proposal to convert the lake and its surroundings into a park.

The "Vita" the third of three similar steamers, which are being built at the Neptune Works of Swan, Hunter and Wigham Richardson, Limited, for the British Indian Steam Navigation Co., Limited, for the service of that company between India and the Persian Gulf, was launched on August 24. She is a twin screw steamer, 390 ft. in length by 53 ft. beam by 26¼ ft. in depth, and has accommodation for first and second-class passengers, together with space for a large number of native passengers. The propelling machinery is being built by Swan, Hunter and Wigham Richardson, Limited, at their Neptune Works, and consists of two sets of triple expansion engines with six large boilers of sufficient power for a speed of 16 knots. The auxiliary machinery is very complete and includes 8 steam winches, steam warping winch, steam steering gear, steam capstan, steam windlass, electric light and ventilation, wireless telegraphy, refrigerating machinery, etc.

AMERICAN ROAD CONGRESS, ATLANTA, GA.

"Overtopping all other road problems in its importance is that of maintenance," says Logan Waller Page, Director of the United States Office of Public Roads and President of the American Highway Association. "The destructive agencies of traffic and the elements are unceasing in their activities and it is idle to talk of permanent roads any more than to speak of a house, a fence, or a railroad ties as permanent.

"The public roads to-day, by reason of the exceptionally destructive traffic conditions, are more costly in construction and this is continually increasing with the advance in the prices of labor and material. It is criminally wasteful, therefore, to invest large sums of public money in building the highways demanded by traffic, unless the investment is conserved by adequate maintenance. Without such adequate maintenance a road costing anywhere from $5,000 to $15,000 per mile may go to ruin in a year or two, thus involving a permanent loss of considerable magnitude.

"When it is considered that the aggregate expenditure on roads in the United States is well over $200,000,000 annually, the seriousness of the question is apparent. I look to the conference of highway officials which will be held during the Fourth American Road Congress, which meets in Atlanta, Georgia, on November 9, to devote much attention to road maintenance, and that the accumulative moral effect of their findings will go far towards bringing legislatures and county boards to a realization of the necessity for prompt and efficient action. The roads should be classified and suitable maintenance, in organization and money, provided according to the importance of the representative classes of roads."

One of the questions which the Congress will discuss is that relating to the revision of road laws. A complete compilation of the road laws of all the states will be available for the session devoted to legislation and it is expected that in outlining bases for revision, maintenance will be given particular attention.

OPPORTUNITY FOR CANADA IN PAPER INDUSTRY.

A report from the European continent announces a dearth of sulphite pulp. Quotations on wood pulp have advanced from 92 to 145 shillings per ton in England. On the outbreak of the war 30,000 tons of paper consigned to the United States were on the sea. Of this amount, 20,000 tons had been sold, and the remainder not yet disposed of. The United States annually imports 350,000 tons.

France and Great Britain are beginning to suffer, as the greater part of their paper comes from Germany and Scandinavia. With Germany eliminated, Scandinavia is left to supply both countries. As the Baltic sea is normally open to commerce only between May and November, importers customarily lay in sufficient supply in the later part of the summer to last for the year. The present is the season of lowest supply.

With the Baltic blocked on account of the hostile fleets and with little hope of its being opened shortly, the shortage is being felt more and more each day. Some of the English publishers have already cut down the size of their papers. South American publishers are feeling the stress too, as they also procure paper from Europe. This leaves Canada as the only producer that is not affected which has any surplus paper.

Coast to Coast

Winnipeg, Man.—The engineers of the administration board of the Greater Winnipeg Water District have announced that, while the original estimates for the Shoal Lake scheme totalled $13,045,000, the outlay will be $1,200,000 less than that amount. Total disbursements on the entire project up to September 25 were $946,431.82; and the bank overdraft, $340,354.34.

Calgary, Alta.—Good progress is reported upon the work being supervised by Engineer Winter on the new east-end tunnel, which is to convey the Calgary sewerage system under the Bow River at Fifteenth Street East for the accommodation of Tuxedo Park and other parts of the North Hill. Of a total approximately 900 feet, 285 feet of the tunnel have been constructed, and it is stated that it will take until midwinter to complete the work.

Montreal, Que.—Outstanding features of the work which has been accomplished by the C.P.R. during 1914 are a new machine and erecting shop at McAdam Junction, as well as over one mile of new storage tracks to the yard at that centre; at West St. John, a fireproof elevator with a capacity of 1,000,000 bushels together with an up-to-date power house, also extensive improvements to terminal facilities in that city; at Windsor Station, Montreal, improvements to the passenger and freight terminals, the train shed just completed being one of the most modern and one of the largest now known; at Place Viger, Montreal, the completion of the improvements which have been in progress for three years, and which comprise a station, an hotel and trackage, the erection of which has cost nearly $5,000,000; and the commencement of the Union Station at Quebec. Throughout the year, also, there was completed the double track bridge at Lachine costing nearly $3,000,000 and the new Lake Shore line opened for traffic in June. The commencement of the new station and viaduct at Toronto has been authorized, and is being delayed only temporarily. Other works authorized and now assuming various stages of completion are: the extension of the Kippewa branch line 10 miles in a northerly direction; a 30-mile extension from Expanse to a junction with the Weyburn-Sterling branch of the C.P.R., which will be completed this fall; the line between Swift Current and Empress, a distance of 112 miles, which will be completed this year; the main line cut off from Swift Current to Bassano, of which 150 miles are completed; the 78 miles of the C.P.R. branch from Lacombe to Kerrobert, a new extension; the Alberta-Central Railway to Lochern, a distance of 65 miles from Red Deer; the great tunnel at Roger's Pass, of which one mile of the Pioneer tunnel has been completed; the C.P.R. depot and terminal offices at Vancouver; the Kootenay Central which is now open for traffic, from Golden, 60 miles south, and the work on which is being pushed vigorously between Golden and Colvalli; and the Esquimalt and Nanaimo line from Parksville Junction to Courtenay. Further, the C.P.R. is interested in the Kettle Valley Railway, and in connection with the same it is building a line from Midway to Penticton—a distance of 134 miles, 76 of which are already open for traffic. A line from Penticton to Osprey, 41 miles in length, has been completed; and work has been commenced on a new line between Osprey Lake and Princeton. The Kettle Valley Railway is also building a line 54 miles in length between Hope and Otter Summit; and a part of the track has already been laid. In addition to all this, the C.P.R. has continued its policy of double tracking.

PERSONAL.

W. P. HINTON has been appointed Assistant Passenger Agent of the Grand Trunk Railway with head-quarters in Montreal.

W. S. DAVIS, of Oakville, has been appointed to the Toronto-Hamilton Highway Commission, to succeed C. G. Marlatt, resigned.

C. L. CANTLEY, assistant general manager of the Nova Scotia Steel and Coal Company, is with the Canadian contingent as a lieutenant in the 5th Royal Scots, 13th Battalion.

MAURICE KERNOH, chief engineer of the Australian State Railways, is in Canada, investigating the government ownership, construction and management of railways and canals.

THOMAS ADAMS, of the Local Government Board of Great Britain, has been retained by the Commission of Conservation, Ottawa, to act as adviser in the work of encouraging town planning in towns and cities in Canada.

FRANK W. SKINNER, M.Am.Soc.C.E., has opened consulting offices at 45 Broadway, New York, and in the Crabtree Annex, St. George, Staten Island, and is associated with Mr. C. E. Fowler, C.E., Seattle, Wash. Mr. Skinner will continue in the field of bridge and structural steelwork, foundation and general civil engineering field construction methods, operations and plant with which he has long been intimately and extensively identified, and will also specialize in the preparation of engineering cases for litigation, expert witness research and testimony, preparation and mediation of cases in controversy.

EN ROUTE FOR THE FRONT.

A partial list has been compiled of the University of Toronto men who are now in England with the first Canadian expeditionary force. This contains the following names of students and graduates of the Faculty of Applied Science and Engineering:—L. C. M. Baldwin '14, P. G. C. Campbell (4th year), E. S. Foulds '11, G. G. Blackstock (4th year), B. H. Hughes (3rd year), G. H. Marani (3rd year), H. A. M. Grassett (3rd year), H. F. H. Hertzberg '07 (Chief Engineer, Canadian Bridge Co., Walkerville), H. A. Heaton '14, R. W. Hains (2nd year), T. S. Glover (2nd year), F. L. Erdley-Wilmot (2nd year), D. H. Storms (4th year) and C. H. Mitchell, C.E., '92 (Consulting Engineer, Toronto). Major C. H. Mitchell received an appointment to the post of general staff officer on the headquarters staff of the Canadian division.

ONTARIO CANALS UNDER INSPECTION.

Hon. John A. Bensel, New York State engineer, and the Board of Consulting Engineers of the New York State barge canal, consisting of M. G. Barnes, Wm. H. Burr, Geo. S. Greene, Jr., Joseph Ripley and T. Kennard Thomson are on a tour of inspection of the canals of Ontario.

NAME OMITTED.

In *The Canadian Engineer* for September 10th, 1914, omission was inadvertantly made of the name of the manufacturer of the large combined gas and steam engine unit which formed the subject of the article on Page 413. The engine was built and installed for the Ford Motor Company by the Hoover, Owens and Rentschler Co., Hamilton, Ohio.

NEW CANADIAN MEMBERS, AM. SOC. C.E.

Recent elections to the American Society of Civil Engineers include that of W. Chace Thomson, consulting engineer, Montreal. Mr. Kay Alexander, of Grant, Smith and Co., and McDonnell, Limited, Revelstoke, B.C., was transferred from associate member to member.

The list of elections to associate membership includes W. C. Bodycomb, superintendent, Victoria, B.C., branch of Westinghouse, Church, Kerr and Co.; J. B. Challies, superintendent, Water Power Branch, Department of the Interior, Ottawa; H. Osborne, resident engineer, Kettle Valley Ry. Co., Hope, B.C.; and J. C. K. Stuart, first assistant engineer, Mount Royal Tunnel and Terminal Co., Montreal.

EDMONTON BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Edmonton branch of the Canadian Society of Civil Engineers held its first general meeting since the organization was affected, at its headquarters in the University of Alberta, on October 1st. The meeting was largely attended by local engineers, and a programme was arranged to be carried out during the coming season. The chairman of the branch is Professor W. Muir Edwards, University of Alberta, and the secretary-treasurer is Mr. L. B. Elliot, Box 957, Edmonton.

COMING MEETINGS.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.—Annual Convention, Grunewald Hotel, New Orleans, La. October 20th to 23rd. Secretary, Mr. McFall, Roanoke, Va.

ALABAMA GOOD ROADS ASSOCIATION. — Nineteenth Annual Convention will be held from October 21st to 23rd at Montgomery, Ala. Secretary, J. A. Rountree, 1021 Brown Marx Building, Birmingham, Ala.

NORTHWESTERN ROAD CONGRESS.—Annual Convention, to be held at Milwaukee, Wis., October 28th to 31st. Secretary, J. P. Keenan, Milwaukee.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Charles Carroll Brown, Secretary, Indianapolis, Ind. Meets at Somerset Hotel, Boston, Mass., October 21st, 22nd and 23rd.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

WASHINGTON STATE GOOD ROADS ASSOCIATION.—Convention to be held at Spokane, Wash., November 18th, 19th, and 20th. Secretary, M. D. Lechey, Alaska Building, Seattle, Wash.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

EIGHTH CHICAGO CEMENT SHOW.—To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.

Volume 27. Toronto, October 22, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

LARGE HYDRO DEVELOPMENT ON THE ST. MAURICE RIVER

PRELIMINARY WORK ON THE 180,000-H.P. HYDRO-ELECTRIC DEVELOPMENT OF THE LAURENTIDE COMPANY AT GRAND MERE, QUE. — SOME DETAILS OF THE CONTRACTOR'S PLANT.

THE Laurentide Company has under construction at Grand Mere, on the St. Maurice River, a hydro-electric power plant, the ultimate capacity of which will place the company among the largest power producers in Canada. The new development is designed for an installation of 9 units, developing 20,000 h.p. each. Of this amount only 120,000 h.p. will be developed at the present time. It was expected that 3 units, developing 60,000 h.p., would be ready for operation early in November of the present year, but the temporary curtailment of operations, due to the European war, will prevent such substantial completion this year.

The St. Maurice River is one of the largest tributaries of the St. Lawrence. It takes its rise in the watershed dividing the St. Lawrence slope from that of Hudson Bay. It flows from west to east, about 350 miles, through a mountainous region, and is broken frequently by a series of cascades. The more important of these are the Shawinigan, La Tuque, Grand Mere and the Rapids des Hetres, nearly all of which are utilized by large industrial concerns. Grand Mere is situated about 90 miles north-east of Montreal, where the river drains an area of about 17,000 square miles. The point at which the development is being conducted is between two islands, one of them Grand Mere, which bears a rock with a remarkable resemblance of an aged woman, whereby the name was originally derived. The other is a triangular shaped, rocky island, about 600 ft. in width.

Fig. 1.—View of the Laurentide Co.'s Plant at Grand Mere. Inset Shows Channel and Grand Mere Rock.

The work was commenced in January, 1913. For years previous to this the Laurentide Company, manufacturers of pulp and paper, operated a dam and power house on the west shore of the river, the main channel remaining practically unharnessed. Fig. 1 is a view of the plant, while the inset shows at closer range the old

channel where the first development took place. The river here is 1,100 ft. in width with a bay on the eastern side. Power was obtained by utilizing a head of 45 ft., acquired by the construction at different times of three dams of 250 ft., 75 ft., and 350 ft. length respectively.

In the present project for utilizing the entire flow of the river the erection is involved of a power house 457 ft. in length x 137 ft. in width, to extend diagonally across the west channel of the river at a point about 200 ft. farther downstream than the old site. A concrete spillway dam 1,700 ft. in length is to extend from the channel corner of the power house, through the island, across the east channel to the shore side of Bee Island, where it deflects at a sharp angle to the shore above. Its height varies from 65 ft. at the deepest point, near the power house, to 4 ft., at the shallowest, which is on the site of the large island. The construction of this dam for utilizing the entire flow of the river has necessitated cutting this island of Grand Mere down to water level in order to provide a sufficient length of spillway to control the water level above the falls during spring floods. A triangular area 400 ft. x 300 ft. with considerable depth, and constituting a mass of approximately 600 tons of solid rock, is being removed. The rugged pinnacle which gave the island its name is being carefully cut and conveyed to mainland, where it will be re-erected.

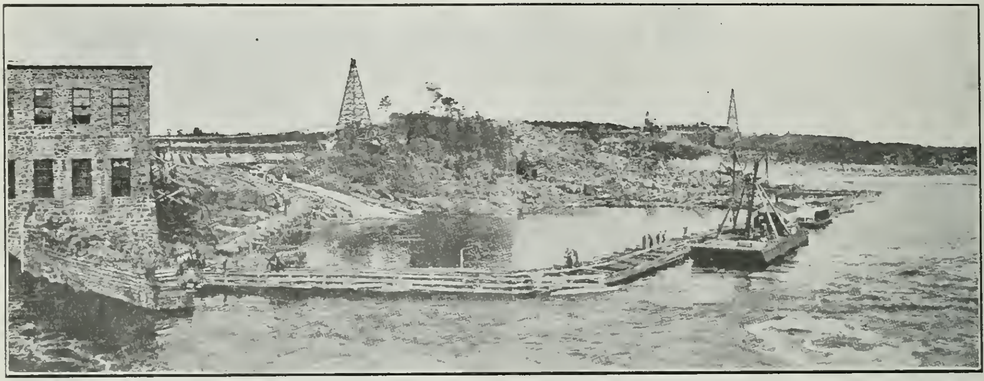


Fig. 2.—General View, Showing Present Power House and Dam, One of the Cable Towers, Cofferdam Under Construction, Main Island, Crushing and Mixing Plant, and the Main Channel of the St. Maurice.

In the new development the natural fall of 45 ft. will be raised to a total effective head of 77 ft. When the cofferdam, which is now diverting the river during the construction of the power house, is removed, the water will be backed up the river for a distance of about 15 miles.

In addition to the dam and power house construction, a tract of land, previously used by the company as storage yards for logs, had to be raised through a height of 10 to 15 ft. in preparation for the new water level.

The consulting engineers for the company are the Geo. F. Hardy Company, New York, and the contractors, the H. E. Talbott Construction Company. Operations were commenced immediately after signing the contract in January, 1913. Preliminary work by the contractors included the organization of force and equipment, together with preparatory operations in connection with the cofferdam below the falls. This could not be built until after the spring floods. The early part of the season saw the completion and pumping out of the cofferdams. The first was built on top of an old wooden crib dam previously constructed by the company, and dewatered the power house site from above. Considerable difficulty was experienced, however, in the construction of the lower cofferdam which extended across the tailrace at an average depth of about 20 ft. of water for a distance of about 600 ft. Wooden cribs, about 20 x 12 ft. in dimension, were filled with stone and sheeted with piling and canvas, thereby rendered watertight. These supported the dam. The placing of the cribs necessitated

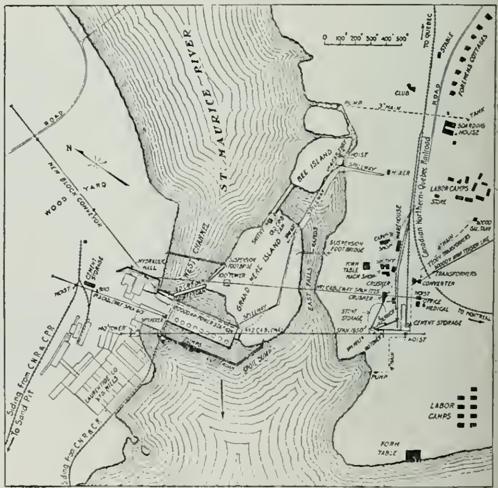


Fig. 3.—Contractor's Construction Camp, and Layout of Present and Proposed Development at Grand Mere.*

considerable dredging as the rock-bottom was covered with layers of debris, including bark, timbers, boulders, etc. In addition the rock surface was very irregular Fig. 2 shows the cofferdam under construction. It also

*By courtesy of *Engineering News*.

shows the present power house, the main island and channel.

Cofferdamming in the west channel was completed in August, 1913, and was immediately followed by excavation work for the tailrace and power house in addition to the erection of more extensive construction camps.

Fig. 4.—(Right) Power House Excavation With Draft Tubes, nearing Completion. (Left) Closer View of Completed Draft Tube.

These camps and their equipment have many distinctive features. They are located on the east side of the river, opposite the present mill site, as shown in Fig. 3, and are fully equipped with crushers, carpenter and blacksmith's shops, material bins, etc., in addition to the housing quarters for laborers. The need for a judicious arrangement of camp for the rapid and economical conveying and placing of material and supplies may be gained from the following: Over 2,000 carloads of lumber, cement, etc., are required for the work. The excavation will approximate 150,000 cu. yds. of rock and 250,000 cu. yds. of earth. About 175,000 cu. yds. of concrete will be required, with 1,000 tons of reinforcing steel and nearly 2,000 tons of structural steel.

The rock removed from Grand Mere Island is transported in large, flat buckets by Lidgerwood cableways 1,125 ft. in length, with a 2¾-in. cable suspended from towers 150 ft. in height, across the river and island. Cars, running on transverse tracks over the cut, convey the rock to the cableway, where it is hoisted, carried to the eastern bank and dumped into serving bins for the crushers. It is to be noted that all the crushed stone used in the concreting work is provided in this way.

The rock is crushed in a large gyratory crusher, assisted by a small reciprocating crusher into which feeds the extra large pieces from the main crusher. The broken stone is conveyed by belt (as are likewise the bags of cement from the cement storehouse) to the mixer. Another crusher operates in the sand and gravel pit to crush the larger stones rejected by the screens through which the gravel is passed.

Another cableway of 7 tons capacity and 1.650 ft. span conveys the concrete from the main mixing plant across to the power house and over a portion of the dam, while another of 600 ft. span conveys concrete from an auxiliary mixing plant on the west side of the river close to the power house site. On the 1,650-ft. span cableway a bottom-dumping bucket is used for carrying the concrete. The dumping is effected by releasing the tension on the ropes by which the bucket is traversed on the cableway, this tension ordinarily holding together the two overlapping hinged leaves which form the bottom of the bucket. Slacking the ropes allows the leaves to swing apart, thereby dumping the material. The bucket holds 2.4 cu. yds. of concrete and empties itself clean when dumped. During operations last summer it gave very rapid service and conveyed 450 cu. yds. of concrete over a distance of 1,100 ft. in the usual 10-hour shift. Hoisting towers with gates and chutes are used extensively in a distribution of concrete in the construction of the power house. Electric hopper cars convey the concrete from the cableway to the hoisting towers. In places not readily accessible to the cableways portable mixers are used.

The completion of the spillway over the eastern channel will be attended to by a fourth cableway of construction similar to those mentioned above.

While work was in full swing during the earlier part of the present season about 400 cu. yds. of concrete were mixed and placed daily, the excavation and crushing capacities being sufficient to provide rock aggregate at this rate. A certain amount of concrete work was effected last fall but the greater majority of it has been put in this

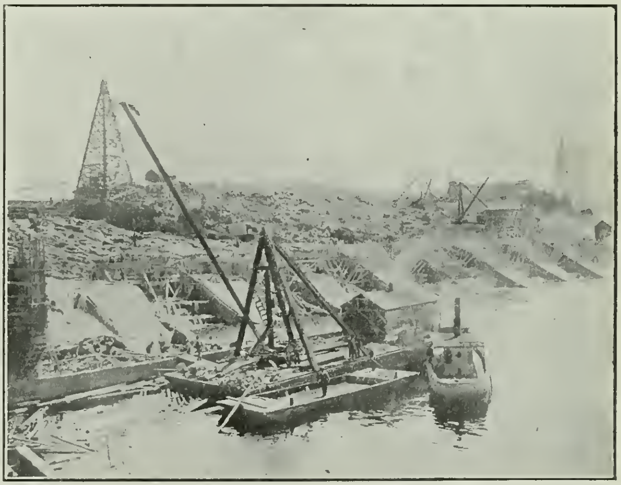


Fig. 5.—Recent View of Power House Construction.

season. It was delayed early in the summer owing to spring floods, which had not subsided from the power house site until early in June. Last Fall's operations on the power house structure consisted of the placing of the draft-tube forms and the pouring of concrete for the lower section. A portion of the adjoining dam was also constructed and the whole was brought above the normal

water level in the tailrace, to approximately the elevation of the scroll chambers. The lower cofferdam was then removed, it being no longer necessary. The draft-tubes were completed in February, 1914.

Since June of this year the power house and dam structures have been pushed with great rapidity, concrete being poured day and night. By August the steel work for the power house was practically complete, the wheel pits were finished, the partitions between gate openings were concreted, the turbine casings were ready for concrete, and the walls were carried up past the floor level of the generator room. About half of the dam was constructed in the east channel and the removal of the top of the island was nearing completion. The penstocks and practically all of the concreting of the scroll chambers and control devices were in place by the end of August. Late operations have included the construction of a cofferdam on the bed of the river at the wide channel on the east side. Here there is about 15 ft. depth of water and the current is exceedingly strong. A channel is being excavated through the centre of the island to provide a water course for the river and a passage for logs of the lumbering interests on the St. Maurice.

Electrical energy for the construction motors and for lighting is supplied from the Shawinigan Falls plant, four miles farther down on the St. Maurice. Current is transmitted at 50,000 volts and is stepped down by three 1,000-kw. transformers to 2,240 volts. A part of the current is further stepped down to 370 volts, by a bank of 100-kw. transformers, and then converted to 600 volts d.c. for operating the d.c. motors. Another portion of the 2,240-volt current is stepped down to 450 volts, by three 75-kw. transformers. Current for lighting purposes is delivered to the circuits at 230-115 volts.

The 9 turbine-generators, when installed and in operation, will provide the Laurentide Company with considerable surplus power, which will undoubtedly extend the fields of the industry in the St. Lawrence Valley. No arrangements have as yet been announced concerning the sale of the surplus. The company will perhaps require 25,000 h.p. for its own needs and it is stated that this alone will mean the saving of a bill for over 65,000 tons of coal, costing over $4 a ton, apart from a general increase of deficiency of operation throughout the mills. The estimated cost of the development is $4,200,000 exclusive of transmission lines or the cost of changes in the paper and pulp plant owing to the electrification of the entire manufacturing system.

WATER-PROOFING CONCRETE.

The following mixture has long been used by the United States Army engineers in water-proofing cement: One part cement, two parts sand three-quarts of one pound of dry powder alum to each cubic foot of sand. Mix dry and add water in which three-quarters of one pound of soap has been dissolved to each gallon. This is nearly as strong as ordinary cement, and is quite impervious to water, besides preventing efflorescence. For a wash, a mixture of one pound of lye and two pounds of alum in two gallons of water is often used.

American cast-iron pipe makers are turning their attention with greater interest to the Latin American market in view of the recent developments. This change, when it comes, will greatly strengthen the opportunity to obtain a large part of the business of the various Central and South American countries, which at present goes chiefly to England, Germany and other European nations.

HOW ENGINEERS MAY BEST USE TECHNICAL JOURNALS.

While much publicity has been given to the usefulness of the technical journal to the busy engineer, and to the proper methods for taking fullest advantage of the services which it renders, it still remains a problem that can best be met by the individual. Many men have many ideas as to the most efficient manner in which the engineering journal may be made of lasting service. All agree that it is indispensable—the differences of opinion centre around its application to each engineer's peculiar needs. There are engineers of all ages of manhood, and engaged, as we are told, in upwards of 110 accurately segregated branches of engineering. Requirements naturally afford leeway for wide variation. It is very gratifying, therefore, to have the instructive lesson which is contained in a paper read by John W. Alvord, consulting engineer, of Chicago, before the Convention of the Federation of Trade Press Associations, held in that city in September. Mr. Alvord views the problem from the standpoint of the young, the middle-aged, and the veteran engineer. His hints to each on how to read, and how to preserve, engineering data are of extreme value. We extract the following from his paper:

That we cannot keep abreast of the times without reading the engineering journals is obvious. That if we carefully read all the engineering journals in our chosen specialty we would have no time left to earn a living is easily capable of demonstration. What, then, is the proper attitude to adopt toward this ever-increasing flood of information that pours in upon us so relentlessly?

If we look about us to see how our fellow engineers solve this matter we shall find a great variety of attitude toward the problem. Some engineers simply do not take engineering journals; reading one occasionally here and there as opportunity offers. Others take all they can afford to take and let them pile up around the office, often unopened and unused. Others still limit themselves to a select few, which they carefully bind and shelve. Still others read journals when they can, and throw them away when they move on. As a rule, however, the engineer prizes his technical paper, and endeavors in some ill-defined and formless sort of fashion to preserve its information for future use. Generally he fails to find any practicable scheme which makes his rapidly accumulating material of much value to him after it has once passed under his eye, and for a large number of engineers, technical journals are only professional newspapers with which to idle away an hour or so and satisfy their curiosity. That their value is something much more than this, or should be more than this, is so apparent as to need no denial.

The problem of the engineer with his technical paper is much affected by his age, station and aim in life. To the man who is engineering only to get money and more money, the engineering journal is a newspaper, in which he may notice mainly where there are better jobs than his own that may be sought after and perhaps obtained. To the man who is anxious to fit himself every year of his life for something better it is an opportunity, quite unequalled many years ago, for a great variety of study. To the young engineer the engineering journal, properly read and noted, is a part of a post-graduate course in engineering. To the middle-aged man it is a mine of data, bearing in all sorts of ways on his work; and to the mature specialist only does it begin to become burdensome by its repetition of experience, and its volume of

matter on subject which has already, to him at least, been well digested. Let us see if we can outline how each of these classes can get more profit out of the matter contained in the engineering journals than do the careless or the indifferent, who, after their journal is once looked over, let it go to waste or idleness.

The young engineer and the college graduate need, most of all, practical experience. It is safe to say that engineering literature will never have any proper perspective for him until he has been connected in some capacity with engineering work himself, be it in ever so modest a capacity. With the actual doing of engineering work, however, should come contemporaneously the reading of technical journals, particularly along the lines in which he is working. Nothing can be more instructive, broadening, and enlightening to a man doing a particular kind of work than reading about similar work at the same time. It follows, therefore, that the young engineer should as early as possible, take at least one first-class engineering journal and own it himself; bind it if he can afford to, but lay it away in an orderly manner, in any event. If he can afford two journals so much the better, especially if they are selected so as to widen his outlook.

It is to be doubted if laborious reading of all kinds of engineering articles all the time is advisable for anyone. Mere quantity of reading is mentally detrimental. If one might advise, it would be to suggest enforced systematic reading of all articles particularly bearing on the line of work the reader is immediately engaged upon, and the optional reading only of such other articles as interest him. This ought not to be much of a task. In course of time as his experience broadens, engineering reading will become less burdensome and more interesting because its relation to practical matters will be more and more appreciated, and the discriminating use of engineering literature better understood. Of course, all this applies to engineering societies as well; but that is another story.

It is probably not wise for the young engineer to indulge extensively in card indexes, filing systems, and the like, for topically arranging his available engineering journal articles. Few men know very early in life where fate and interest will land their future attention, and filing systems and special indexes are expensive and time consuming, and when indulged in without definite aim nearly always quickly become too voluminous and thereby useless. If any suggestions are made along this line, it would be to start a loose leaf, letter-size (8½ x 11-in. page) notebook and note in it (separate pages for separate subjects) only what appears to be extremely useful, either in exceedingly brief abstracts from engineering articles, or diagrams, costs, etc.

The young engineer is tempted to read much about large enterprises—the Panama Canal, big bridges, astonishing tunnels, great dams. This does no harm, and probably holds his interest for the time being. Gradually he learns that, for him at least, the chief value of the technical journal does not lie in its dramatic side, necessary as that may be for our general information, interest and pleasure, but its chief value lies in a fund of small things, which make up routine work of the ordinary every-day job. These are to be watched for, and noted, as practically useful to the average man.

We next come to the man in early middle life, actively engaged in his profession, and note at once that his problem with the technical journal is the absence of "time." Absorbed in a multitude of responsibilities, harassed with unexpected difficulties, worn out at night with the long day of strain, how shall he derive any useful good from the multitude of journals which his more ample income can readily afford, but which pile high on his table after every brief absence from the office? Whether or not such an engineer shall make any effort to systematically assimilate, file, and study current technical journals depends in part upon the nature of his routine. If he is largely engaged in administrative work, or is a salaried officer in a large enterprise with a comparatively limited range of problem or a limited call for miscellaneous data, he may generally be content with a cursory examination of the engineering journal such as will keep him qualified on his undertaking, and the preservation of such journals in bound form, with the standard published indexes. If, however, he is entering upon novel work, or work presenting a great variety of problems, overlapping into a great variety of fields, ambition will compel him to do more than this, and some form of special indexing will appeal to him more or less strongly as he feels the need more often for research in up-to-date material.

The average editor can judge of a technical article with only a brief inspection—a sentence here and there, a headline, and a moment's reading of the summary and conclusion. Long familiarity with matter of a similar character gives him the assurance that he can detect in this rapid review anything novel, new, or original, and can fairly pass judgment upon it in a general way. The working engineer who has had some experience with technical literature can form the same habit, and save much time. It is really wonderful how much repetition there is in engineering writing and in the production of engineering papers. It thus happens that we are under the necessity of seeing much the same facts and principles repeatedly published in varying form, for some one is always attracted to really read them, with consequent benefit to himself, under the belief that they are new and novel.

The mature engineer notes that a large amount of engineering literature is of the purely descriptive order, merely giving outline of work that has been accomplished, without going into reasons or principles. All this kind of writing is valuable and useful, and has its proper place, but all of this class of literature has its limitations. One of the most severe of its limitations is that it rarely describes mistakes, errors of judgment, or failures, and in these lie the most valuable lessons to the seeker after truth. One is obliged to read between the lines or read with reservation, much as one does in reading accounts of battles in the daily press. It is always wise to look back and note the origin of the despatches in such cases.

A tremendous lot of engineering literature is written which is of little permanent value. Often it represents the writer's struggles to understand a subject. Often it is compiled largely from a desire for publicity. Fortunately the editors of the technical papers can limit this kind of reading by care in selection.

But amid all these drawbacks a discriminating mind will always find a great deal of wheat amid the chaff, and the wheat that will be gleaned will be of differing kind and amount, depending upon the type of mind of the reader, his present problem, and his desire to systematize his information. What, therefore, shall he do with his special selection when once he thinks he has separated it from the flood of raw material?

Several courses are open to him:

First, he may rely on his memory and the published index to his bound volumes. It is safe to say, however, that few engineers really make much practical use of this method. The intervening index and the bother of a search prove to be discouraging to that degree that a proposed reference search is abandoned in about one-half the sug-

gested attempts. The ideal filing system is one in which, with the least amount of effort, one can put his hand immediately and accurately on the thing itself, be it a book, a pamphlet, or a data sheet.

Second, he may keep a special card index of important data and reference to valuable articles. This at once involves labor and attention which few busy men can give and which, if done by assistants or librarians, largely loses its personal value to the one who needs it. The same objection as to the discouraging effect of intervening indexes holds good here, too, and it is further safe to say that of all the contrivances for indexing the most difficult to handle readily and examine rapidly is the card index system.

Third, he may abstract important data in a limited way on loose leaf transparent paper, standard letter-size, and he may remove or detach articles of special value from out his journals, to be filed in regular office file system, like correspondence.

The writer has tried all of the above methods at considerable cost in time and patience, and has, for many years, settled upon the third method. With all its admitted limitations it seems to be the best for an office which is expected to find out information on a great variety of subjects in a limited time, and with the least amount of effort.

Some description of its practical workings may be of interest:

All the technical papers of the office pass on to the desk of the head of the office and are at least looked over (not read) by him. Articles important to his particular specialty are checked with pencil, and articles of especial interest are looked over with care and double checked. Once in a long while data important enough to go to the data file are noted. This is either especially abstracted by the stenographer, or, if a diagram or cost data, perhaps traced in the drafting room, all on transparent paper for copying purposes. Special data of this kind, on $8\frac{1}{2}$ x 11-in. sheets, are filed in the office data file (a separate but common standard correspondence file). From the data file loose-leaf working note-books are made up from blueprints for office or travel purposes. They are altered, refilled, amended and sorted back from time to time as needed to keep them of usable volume and usefully up-to-date.

The technical journals, with checked articles, go to the office clerk or the stenographer at odd hours, or the librarian if one can be afforded, and the useful articles are removed by tearing them out with a ruler. They are folded, usually once, to standard size, with one edge lap left for binding, and are then filed in a subject index file, like current correspondence. The Dewey Decimal system, especially arranged for the office, is used, but only as a general subject plan. When the file is full, portions of its contents, especially that which is most useful, are simply bound in plain pasteboard covers and placed in the library shelves, with titles. Such a book (or many books) would contain all the recent articles thought to be of special value on a given single subject. The remaining portions of the technical paper are thrown away, but in a large office, warranting the expense, duplicate bound copies can be kept as well, with the general published index as their key.

The objections to this system are as follows:

First, it is too expensive for any but the most important offices doing specialized work. Second, data accumulate almost too fast unless rigidly kept down to a minimum. Third, it requires some personal attention of the head of the office, a competent assistant, or the employment of a regular librarian.

The advantages are:

First, it compels the office head to know all the time what is being published in current engineering literature, if only by inspection. Second, it removes all intervening indexes between the searcher and the final repository in bound volume. Third, it keeps one's library usefully up-to-date on all lines in which one should be especially interested. Fourth, it is economical of final shelf room and cost.

Obviously, one should not start so elaborate a system as this unless he is fairly sure of the special line of engineering to which his life will be devoted. Otherwise, waste effort and discouragement will be certain. It is not to be recommended to the young man, but only to the mature man of early middle life when his work clearly indicates the necessity for it. It is, however, the prime requisite of the engineering specialist. To him some such a system is invaluable. Not a few consulting engineers use this standardized system interchangeably, particularly the data file, thereby greatly increasing its usefulness to one another as a joint effort.

We come finally to the mature and experienced engineer of advancing years. How can he make engineering and technical literature of use? It is safe to say that when an engineer has much passed fifty or sixty years of age and has led an active life, his need for engineering literature lessens. Out of the mass of detail which seemed to him so overwhelming and endless in his youth and early manhood, fundamental principles emerge like peaks out of the clouds, and upon these as foundation all detail classifies itself simply and naturally, and therefore, he feels less need for accumulated data or particular description. Probably no one enjoys engineering reading as does the mature engineer, for he can read between the lines and find much to instruct as well as interest, and yet while he is probably the most interested and intelligent reader of engineering literature that the journals have, his ambition as a collector is gone and filing systems no longer appeal to him.

If his acquaintance is wide, he reads with interest the accomplishments of his friends, and the addresses of society presidents and articles on the ethics of the profession. Of failures he is the keen student. The personal column appeals to him, and if he is of right-mindedness he is conscious of more pleasure than formerly in the accomplishments of those who have succeeded and succeeded well in dire and burdensome responsibility. More often than the young man he will turn back for his satisfaction to papers that served him well in times past, and perhaps smile at the lack of improvement that later attempts to deal with their subject often show.

Technical papers, along with the technical societies and their proceedings, form the repository of the professions; they are the interchange of experience, the common store upon which we all draw. Without them we would be strangely helpless. We are indebted to every one more or less who records his experience for the common use, and that debt we should endeavor to helpfully repay in kind, but wisely, concisely and thoughtfully.

The Fort William plant of the Steel Company of Canada, on which construction was started last year and not completed owing to the dull manufacturing season, has resumed operations and a large gang of men is at work on the completion of the building. The plant will be ready for operation between November 15th and December 1st.

ANALYTICAL TESTS AT WATER PURIFICATION PLANTS.*

THE elimination of unnecessary analytical work is a matter that needs consideration at this time quite as much as the making of the necessary tests.

Laboratory practice at various purification plants has shown that many of the determinations which are ordinarily included in the standard water analysis schedule are here of little or no importance. For example, the determination of nitrogen in the usual forms of free and albuminoid ammonia, nitrites and nitrates serves no particular purpose in water purification except in special cases. They neither assist the superintendent in the operation of the filter, nor give any adequate idea of the safety of the filtered water. On the other hand, some of the simpler physical tests, such as numerical determinations of turbidity, color and odor, microscopical examinations and tests for alkalinity, iron and carbonic acid, have come to be regarded as most valuable; and in special cases various other tests, such as dissolved oxygen and manganese. Bacteriological tests are, of course, important.

One step in making an analysis of water has never received half the attention that it deserves, namely, sampling. Of what value is it to use analytical methods of great refinement if the samples themselves are not representative, if the mass of water from which the sample is taken is not homogeneous, or if the water changes in character from one day to another? Samples for chemical analyses are almost never larger than 4 liters (1 gallon); and samples for bacteriological analyses are seldom larger than 100 cubic centimeters (4 ounces), while the quantities actually used for the different tests are still smaller. In counting the number of bacteria, the quantity is less than a thimbleful.

On the other hand, we know that bodies of water are not homogeneous. In a lake or settling basin there are vertical and lateral variations; a river is constantly changing, not only in volume but in the character of the water; filter effluents vary, especially the effluents from mechanical filters where the runs are short and the rates are high. The causes of these variations which affect the results of water analyses through unfair sampling are so numerous that they cannot be studied by themselves, and the only course left is to apply to them the laws of probability, or, in other words, to arrange the data secured in some such way that the importance of the inevitable variations may be indicated and an index of the character of the water examined be obtained.

Thus we see that a question of fundamental importance is that of frequency of collecting samples. The question is, how often must samples be taken to obtain reliable results? As a general proposition it may be stated that the frequency of sampling should depend upon the frequency of change in the character of the water examined. For a water of constant quality, a few samples taken at infrequent intervals may serve to give a fair idea of the water, but if a water be subject to great fluctuations in character, a few samples taken at long intervals might or might not give a fair idea of the water. The reliability of the average result will be determined by the laws of probability. The average result does not tell the whole story, for it eliminates the individual results, and a water supply should be safe and wholesome all of the time.

*From the report of the Committee on Statistics of Water Purification Plants submitted at the annual convention of the New England Water Works Association, September, 1914.

The frequency of sampling has a limitation, which is controlled by practical and financial considerations. In a small plant the cost of daily analyses would usually be prohibitive, and even weekly analyses might be a burden. It would be recognized, however, that results based on infrequent samples are less valuable than those based on frequent samples; and that irregular sampling gives the most unreliable results. In order to emphasize this point it seems desirable to establish certain grades of control of operation, based upon the character of the records kept, as follows:

First Grade: Water purification plants under first-grade supervision are those where the analyses of the filtered water are made one or more times a day, and where engineering and such other data regarding the operation of the plans as are necessary are collected by one or more attendants constantly employed.

Second Grade: Water purification plants under second-grade supervision are those where analyses are made regularly, say once a week or once a month, by a trained analyst, and where an attendant constantly on duty makes simple daily tests.

Third Grade: Filter plants under third-grade supervision are those where analyses are made irregularly and infrequently, and where no daily tests are made by the attendant.

Sometimes it is difficult to grade the supervision given a plant. As an example, we have the Lawrence city filter, where daily tests are made during five winter and spring months of the year, and weekly tests during the remaining seven months. Here frequent analyses were made during those seasons which were most critical. This might be termed a mixed supervision of the first and second grades.

This grouping should not be considered as necessarily casting a stigma upon second- or third-grade supervision. Some water supplies may not demand first-grade records. In general it may be said that the safer the raw water, the lower may be the grade of analytical supervision. In other words, polluted waters require the purification plant to be operated with a higher factor of safety, and to this end a more careful analytical control is needed. Stored waters are safer than unstored waters, and with them a lower degree of analytical supervision may suffice. A corollary to this would be that small plants which cannot afford high-grade supervision of filters should endeavor to protect the quality of the supply by storage or by incorporating a large factor of safety in the design of the plant.

NOTE—The Committee on Statistics of Water Purification Plants, acting for the American Water Works Association, consists of Geo. C. Whipple, chairman; Robt. S. Weston, Frank D. West, Frank W. Green and E. E. Lockbridge. Blanks have been prepared illustrating the recommendations of the committee regarding the form of report, tests to be made and methods of recording results. These are arranged to show the analytical data by months and years, and are as follows:

Table 1.—Chemical and Microscopical Character of Raw Water.

Table 2.—Turbidity and Color of Raw Water.

Table 3.—Bacteria in Raw Water.

Table 4.—Chemical Character of Water Delivered to Mains.

Table 5.—Turbidity and Color of Water Delivered to Mains.

Table 6.—Numbers of Bacteria in Water Delivered to Mains.

Table 7.—Numbers of B. Coli in Water Delivered to Mains.

WIDTH OF ROADS FROM THE POINT OF VIEW OF ECONOMY.

An article appeared in the September issue of "Conservation" showing that in some instances wide streets may be actually cheaper than narrow ones. The author is Mr. R. Thomas Adams, senior town-planning adviser to the Local Government Board of Great Britain and recently appointed to act in the same capacity for the Commission of Conservation, Canada.

Some points in Mr. Adams' article are given below:

The advantage of wide roads is sometimes questioned. Where they are made in advance of requirements they may impose an extra burden on the existing ratepayers, for the benefit of posterity. This burden may be too great, even having regard to the ultimate benefit which may be derived, but of course this entirely depends on the degree of width and the extent of cost incurred. No definite standard of width can be satisfactory for adoption under all circumstances.

The ultimate economic gain to the community is one factor, but it is only one factor, in giving the matter consideration. The local circumstances may make it necessary for each road to be considered on its merits. The cost of expropriating land, the existence of buildings, the physical character of the site, the immediate gain as distinct from the prospective gain to the community must all be considered. There are, however, some general principles which afford us guidance in regard to these matters; for instance, where it is definitely known that a road will be required for use as a surface railway or tramway the width of the road should of course be greater than where such use is not contemplated.

There is no necessity for a road to be actually constructed in advance of traffic requirements. On that point there need be no difference of opinion. The sole question is whether the land should be acquired or earmarked for the road in advance of the full width being required. The investment made by the community to-day for the benefit of the future citizens may therefore be limited to the acquirement of the extra land. The construction can be spread over as long a period as may be desirable, but if the land is not purchased at the outset it may be assigned to private uses, such as the erection of expensive buildings, which would make it prohibitive to carry out the widening when actually needed. These possible losses and hindrances to the future development of a town must of course be considered, as well as the question of immediate gain, but the immediate gain, or rather absence of loss, probably makes the wider appeal to the ratepayers.

It is therefore of interest to have an example such as that afforded by the construction of a wide road at Liverpool, England. The city engineer of Liverpool has made extensive experiments in the making of wide roads round the suburbs of the city. Recently he demonstrated to his council that it was cheaper to make a road 120 feet wide than 80 feet wide.

The cost of the two roads, 80 feet and 120 feet wide respectively, is given by the city engineer as follows:

Comparative cost of widening a 40-foot road to 80 feet (tramways paved) with widening to 120 feet (tramways in grass).

Widening to 80 Feet.

Cost of land, 13⅓ yds. @ 5s.	£3: 6: 8
Street works per yard lineal	£7: 2: 6
Tramways (including paving) 1 yard @ £6: 15: 0	£6: 15: 0
	£17: 4: 2
	= £30, 286 per mile

The above estimate provides for the reconstruction of the old road to suit new levels.

Widening to 120 Feet.

Land for new road, 13⅓ yds. @ 5s.	£3: 6: 8
Street works per yard lineal	£4: 13: 7
Tramways (in grass) including land, 1 yd. @ £6: 16: 8	£6: 16: 8
	£14: 16: 11
	= £26, 128 per mile

This estimate does not provide for any alteration to the old 40-foot road.

It will be observed that in order to make the 80-foot road it is necessary to reconstruct the old road to suit the new levels, but that no such reconstruction is necessary in the case of the wider road. It is also important to note that the estimate for the 120-foot road includes the cost of the extra 40 feet of land for tramway purposes.

These circumstances are of course special to a certain extent. Instances might occur where the reconstruction of the old road would be necessary in either case. But even then the only extra cost per yard in making the wider road would be one-eighth the difference between £6: 15 and £6: 16: 8, the cost per yard of the tramway.

In this case the important point is that it is much cheaper for the Liverpool corporation to make a road 120 feet wide than 80 feet wide. All the ultimate advantages to the city are therefore additions to the immediate gain. The latter, however, is not limited to the saving of cost. In Liverpool they are finding out that these wide tree-planted roads are having the effect of keeping the homes of the well-to-do citizens within the city boundaries. Those who will not erect large houses in narrow uninteresting tramway routes are building them on the spacious highways which Mr. Brodie is constructing. Liverpool has for a long time suffered from the migration of its large ratepayers into outside districts. This not only increases the rates all round in consequence of lowered rateable value, but removes from the city those who, while in residence, subscribe to its charities and take an interest in its social life. That the policy of making wide avenues with grass margins is helping to retain these well-to-do inhabitants within the city limits is one of the indirect advantages which Liverpool claims.

A brisk demand for the product of the paper and pulp mills in the interior of Newfoundland has resulted from conditions growing out of the war in Europe. Steamers are rapidly arriving to take on board cargoes for England. It is expected that the mills will be obliged to supplement their present equipment, and it is anticipated that new pulp and paper concessions will shortly be in operation.

Milwaukee has a refuse incinerator with a total capacity of 300 tons a day. A 6,000 kw.-hr. turbo-generator is driven by the steam raised in a 200-h.p. boiler. The current from the generator is to be transmitted to a flushing-tunnel pumping station, some two miles distant, which will pump lake water into the north end of the Milwaukee River for flushing and cleaning purposes.

SOME CANADIAN DRYDOCK SCHEMES.

A drydock is to be constructed at Owen Sound by the Canadian Shipbuilding and Dry Dock Company, Limited. This corporation has capital of $2,000,000 and an Ontario charter. The head office is at Owen Sound. The company has authority to manufacture and deal in iron, steel and other metals; to construct and operate drydocks, harbors, elevators, warehouses, terminals, wharves, etc., and to carry on the business of a wrecking company.

The municipality of Owen Sound has decided to grant a subsidy to the company, which amounts to a cash bonus of $10,000 a year for a period of 20 years. This bonus is contingent upon the fulfilment of an agreement whereby the operating company must employ at least 200 men daily for an average of 300 days in each year. The company will be exempt from taxes, except school taxes, for a period of ten years. A site for the dock and plant has been selected on the bay shore of the city. The dock is to be 775 feet long from caisson groove to head peak, 104 feet wide at the top and 21 feet over the sills.

Those interested in the enterprise are Mr. F. F. Wood and Mr. E. D. Pitt Niagara Falls, Ontario; Mr. F. J. Nelson and Mr. John Roche, Buffalo. Mr. Pitt states that plans are being filed with the Dominion government and that the company's plant will be the largest and most complete for ship repair and shipbuilding and have the largest drydock on the great lakes.

The Dominion government has passed an order-in-council for a subsidy to the Amalgamated Engineering Works, Limited, of British Columbia, amounting to a maximum of $5,500,000, at 4 per cent. interest for a period of 35 years.

The subsidy is for the purpose of erecting at Vancouver modern drydocks to cost over $6,500,000. The plant of the company is to be located at North Vancouver, and will contain a drydock 1,150 feet long, capable of being divided into two sections of 650 and 500 feet in length, with a width of 100 feet.

Another large shipbuilding and drydock plant is proposed by the Dominion Shipbuilding, Engineering and Dry Dock Company, Limited, of Vancouver, B.C. Plans and specifications have been completed for the major part of the work. The plant will be located on the Burrard Inlet at Vancouver, B.C., and ultimately will represent an expenditure of about $2,800,000 for machinery, building and construction. It will have a graving dock, constructed of reinforced concrete, 1,000 ft. long and 100 ft. wide. Adjacent to the graving dock will be two marine railways and alongside of dock, wharves will be constructed to serve the traffic of the plant. One of these railways will handle vessels up to 1,000 tons, and the other vessels up from 1,000 to 4,000 tons. Seven shipbuilding berths will be constructed. Lynn Creek, a fresh water stream, located on an eastern edge of the rib will be dredged and retaining walls built on either side. The stream will then serve as a cleaning out basin and also as a fitting out basin.

The buildings for fabrication and general construction purposes will be located directly in the rear of the shipbuilding yards. The principal structures and their estimated costs are as follows:—

Machine shop, 250 ft. x 68½ ft.	$30,000
Pattern shop, 225 ft. x 137 ft.	30,000
Boiler shop, 250 ft. x 68½ ft.	20,000
Blacksmith and general forging shop, 250 ft. x 68½ ft.	30,000
Angle and plate shed, 600 ft. x 100 ft.	60,000
Woodworking shop, 100 ft. x 200 ft.	35,000
Copper shop, brass foundry, etc., 75 ft. x 125 ft.	45,000
General stores building, 75 ft. x 100 ft.	20,000
General office building, 60 ft. x 90 ft.	10,000

These buildings, with the exception of the last two, will be of steel frame construction with corrugated iron covers and concrete floors with asphaltum top. The general stores building will be similar except that the floor will be concrete without the asphalt surface. The general office building will be of brick and wood.

The principal item of expenditure will be for the graving dock; this with its puming plant is estimated to cost $1,500,000. The improvement of Lynn Creek will cost about $225,500. The stream will be dredged to a depth of 25 ft. and a width of 200 ft., for 1,800 ft., and retaining walls constructed on each side. The creek will be straightened out into a straight canal by diverting its channel. Wharves will be built on the top of the western retaining wall.

There will be two main wharves, one 900 ft. long, estimated to cost $12,000, the other 1,200 ft. long to cost $22,000. On the end of the longer wharf a hammerhead crane of 100 tons capacity will be erected. This will cost about $100,000. There also will be two marine railways, one of 1,000 tons capacity and one of 4,000 tons capacity, the cost, with power plant, being $15,000 and $130,000 respectively.

The Lake Superior Dry Dock and Construction Company, Limited, with an authorized capital of approximately $1,000,000, and a bond issue of £157,000, was recently organized to build a drydock at Sault Ste. Marie, Ont. In November. 1913, the city of Sault Ste. Marie voted a subsidy to the company of $20,000 per annum for a period of 20 years, subject to the payment by the company of taxes on a fixed assessment, which would return to the city about $10,000 annually. The Dominion government has granted a subsidy of 3 per cent. per annum on $1,386,528 for a period of 20 years. The bonds are said to have been underwritten in London and Messrs. Hoare and Company, of London, are trustees for the bondholders. Not long ago, the permanent board of directors was elected, the following being the list:—Mr. C. G. Bryan, director of the Canada Steamship Lines, Limited, director of the Richelieu and Ontario Navigation Company, director of Palmer's Shipping and Iron Company, Limited, London, England; Mr. Frederick R. De Bertadano, director of the General Accident Fire and Life Assurance Corporation, London, England; Mr. Rowland Hodge, director of the Northumberland Shipbuilding Company, Limited, of London, England; Mr. Francis Somerscales, late general manager of the Earles Shipbuilding and Construction Company, Limited, Hull, England; and Mr. Percival T. Rowland, barrister, Sault Ste. Marie, Ontario. The company's consulting engineers are Sir Douglas Fox and partners, of London, England.

In June, a payment of $25,000, the price agreed upon for their site, was made to the city of Sault Ste. Marie. Prior to the outbreak of the war, arrangements had been completed by this company, by which their bankers were prepared to advance them a sufficient amount against their underwriting agreements to enable them to commence construction at once. The agent of the contractors, the British Construction Company, and his staff, sailed from England for Canada on July 24th, with the intention of making arrangements to start immediately work on the drydock. The necessary machinery was shipped and is now on the ground. Owing to the conditions brought about by the war, the enterprise will be held in abeyance in the meantime.

The construction of the floating drydock and ship repairing plant of the Grand Trunk Pacific Railway Company at Prince Rupert, B.C., is making good progress. The first pontoon was launched August 24th. The second pontoon or section will be launched during September and within the next 60 days a section of the drydock will be available for repairs to craft in that locality.

The Drydock Subsidies Act of 1910 gives encouragement to enterprises of this nature. This act differentiates between first and second-class docks as follows:—

"A first-class dock shall be capable of receiving and repairing ships of at least 25,000 tons; shall cost not more than $4,000,000; and bonds to this amount or less shall be guaranteed for a term of 35 years.

"A second-class dock shall be capable of receiving and repairing ships of 15,000 tons; the cost shall not exceed $2,500,000; and the bonds shall be guaranteed for the term of 15 years."

Dawson, Yukon Territory, is planning to establish a municipal electric lighting and telephone plant at an estimated cost of $165,000. The Dawson civic league, which is planning various improvements, recently petitioned the Yukon council against the annexation of the territory to British Columbia, and the surrender of its independence.

About 65 per cent. of the permanent way of the Swiss Federal Railways is equipped with steel sleepers. The weight of the sleepers is 25.16 kilos. per running metre, and when the holes for the rail attachments are complete they weigh 72.5 kilos. (159.8 lb.) each. The tensile stress specified is from 35 kilos. to 45 kilos. per square millimetre, and the entire trough piece must be capable of being bent back double without showing any crack. At the switches double-trough sleepers are used, which weigh 125 kilos. (275.5 lb.) each.

SPEED VARIATION BY A GRAPHICAL METHOD

PERCENTAGE SPEED VARIATION FOR DIFFERENT GOVERNOR TIMES AND VARYING AMOUNTS OF LOAD CHANGES IN A HYDRO-ELECTRIC POWER PLANT, INDICATED GRAPHICALLY.

By T. H. HOGG, C.E., (Toronto).

THE problem of finding the percentage speed variation for different times of governor, and varying amounts of load change, is one with which the hydro-electric engineer has often to deal. The number of variables is such that it is difficult to grasp the range and variations unless resort is had to graphical means. The writer has recently had occasion to use such a method, which may be of interest to engineers dealing with like problems.

The methods used in modern hydro-electric plants to preserve uniform speed under various conditions of service are too well-known to warrant full discussion, but it will be necessary to give a brief résumé of the factors influencing speed-regulation in order that the chart illustrated may be understood.

With high head plants, speed regulation becomes increasingly difficult, on account of the increase in the length of the feeder pipe lines, and the necessity for the economical use of the small amounts of water often conserved in costly storage reservoirs.

The amount of energy stored in the moving water of these pipe lines precludes rapid speed regulation, unless other means are used to furnish deficient energy when load is thrown on, while the water is speeding up in the conduit to the new required velocity; and conversely, when load is thrown off, to take up the excess of energy which must be dissipated gradually.

While this adjustment of velocity of flow is being made, the increase or decrease of energy is usually taken up by one or more of the following remedies, *viz.*, synchronous by-pass, deflecting nozzle, flywheel, relief valve, breakplates, governor-actuated pressure regulator or surge tank.

Where the first methods are used, in case of load thrown off, the water is by-passed by means of a valve operating by pressure directly connected to the water-wheel gates and arranged to open as they close; when load is thrown on, dependence is placed on the extra flywheel attached to the wheel to give the additional amount of energy required. Modifications of this may be used, such as a by-pass indirectly controlled by the movement of the governor so that any movement of the governor actuates a relief valve. With load thrown on, however, a limit quickly comes to the available speed regulation on account of the flywheel required. It is to this aspect of the problem that the chart and discussion applies. The method used for the analysis of the problem is that given by Mr. W. Uhl in his paper published in the February, 1911, Journal of the American Society of Mechanical Engineers. The graphical treatment is based on methods illustrated in Peddle's treatise on "Construction of Graphical Charts."

In an open-flume turbine setting, the speed regulation is dependent upon the flywheel effect of the connected rotating masses; the variation being in accordance with the following formula: $s_1 = \dfrac{800{,}000 \times H.P. \times T}{n^2 \times (w\,e^2)}$, where s_1 equals the speed variation or ratio between total speed change and normal speed; $H.P.$ represents horse-power load variation; T the regulating time; $(w\,e^2)$ the moment of inertia of rotating masses, and n the normal revolutions per minute.

The value of s_1 must be modified, due to several causes; the friction load of the generator and turbine remains and will tend to reduce the speed variation. Also, providing the turbine is correctly designed so as to give its maximum efficiency at normal or synchronous speed, the efficiency will be reduced with either increasing or decreasing speed. The amount reduced varies with the type of runner, being greatest for a high-speed, high-power runner, and least for a low-speed, low-power runner, since if correctly designed, the change in efficiency will be greater for a high-speed than for a low-speed runner for the same per cent. of variation in speed. The new value of s_1 to be used we will call s_2, and $s_2 = c\,s_1$ where c is a constant, as follows:

Type of runner (Specific speed)	13.55	20.3	29.4	40.7	49 7 / 62.8	70 97 / 83.78
C	.714	.703	.69	.671	.645	.606

Regarding the value of T in the above. The governor manufacturer will state the time required for a complete stroke of the governor, and experience shows that the time required for a governor to alter the power of a water-wheel after a great or small sudden load change will be approximately constant and equal to the time required for a full stroke or T.

As noted previously, a large amount of energy is stored in the moving column of water when long penstocks are used. Changes in velocity, therefore, involve changes in the kinetic energy, and produce pressure variations or oscillatory waves in the conveying conduits. It is this pressure variation or water hammer which develops when the flow in a pipe line is disturbed by the movement of a gate located either at the upper or lower end or in an intermediate position. These waves or oscillations once set up, continue until they are smothered by the friction on the walls of the pipe and between the molecules of water.

The velocity at which these waves travel is of considerable interest as on this depends the time element of the disturbances. This velocity depends upon the compressibility of the water and upon the nature of the material of which the penstock consists. It is found to vary from 1,000 feet a second for large diameter pipes to 4,500 feet per second for small diameter, and may be figured for any given set of conditions. Knowing this velocity, a, the minimum regulating time of the governor must always be greater than $\dfrac{2\,L}{a}$ where L = length of the penstock, otherwise dangerous interference to regulation, due to speed oscillations, will be developed and extreme pressure heads will exist on the valves and penstocks.

Now, knowing or having fixed the regulating time of the governor for any particular plant having a long pipe line, it is possible immediately to obtain the pressure variation due to any given change of load (velocity). Let us call this pressure variation $\frac{dH}{H}$ with the sign + for governor closing and — for governor opening.

Therefore the speed variation of the unit due to any change of load may be immediately obtained from the following formula:

$$s_3 = s_2 \left(1 + \frac{dH}{H}\right)^{3/2} \text{ for load thrown off.}$$

$$s_3 = \frac{s_2}{\left(1 - \frac{dH}{H}\right)^{3/2}} \text{ for load thrown on.}$$

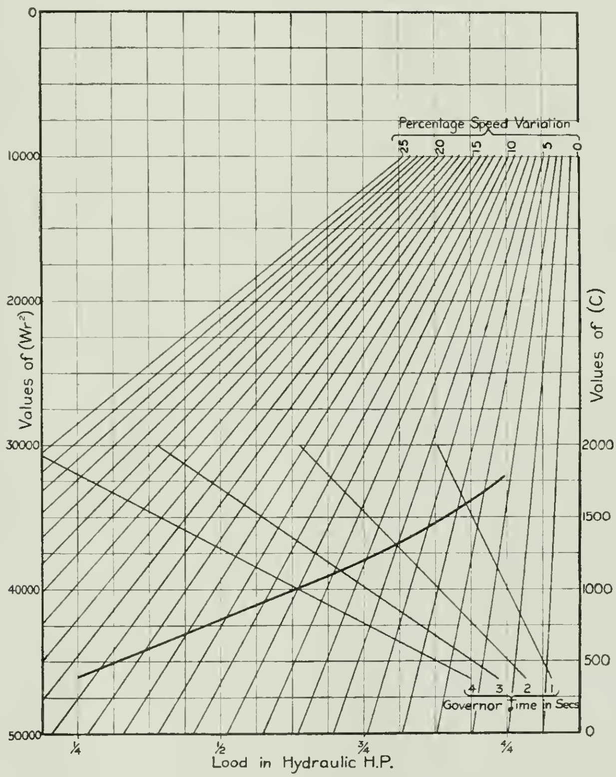
For a closing time of governor T greater than $\frac{2L}{a}$, the pressure increase or decrease $\frac{dH}{H}$ may be found from

$$\frac{dH}{H} = \frac{p}{2}\left(p \pm \sqrt{p^2 + 4}\right)$$

where $\frac{dH}{H}$ = pressure variation

$p = \frac{Lv}{gHT}$

L = length of penstock
v = velocity in penstock
g = acceleration of gravity.
H = gross head



Curve Showing Percentage Speed Variation for Different Governor Times and Varying Amounts of Load Change.

s_2 is the value previously obtained for open flume conditions and is here modified on account of the head variation.

It will be noted that the speed variation of a unit is inversely proportional to the (we^2) of the rotating parts, so that in order to secure any given percentage of speed variation we must install a certain value of (we^2) or flywheel.

T = time of governor
s_3 = speed variation in per cent.

We can now proceed to the construction of our chart.

Let us assume the following example: Two machines of 2,180 h.p. each on one penstock.

Length of penstock L = 1,655 ft.
Gross head H = 535 ft.

Velocity in penstock:

For $\frac{1}{4}$ load on one machine $v_1 = 1.17$ ft. per sec.
For $\frac{1}{2}$ load on one machine $v_2 = 1.91$ ft. per sec.
For $\frac{3}{4}$ load on one machine $v_3 = 2.49$ ft. per sec.
For full load on one machine $v_4 = 3.16$ ft. per sec.

and $n = 900$ revolutions per minute. The type of wheel used is one with a specific speed of about 13, and therefore $s_2 = .714\, s_1$.

$$\text{Therefore } s_3 = \frac{s_2}{(1 - \frac{dH}{H})3/2} = \frac{.714\, s_1}{(1 - \frac{dH}{H})3/2}$$

$$= \frac{.714}{(1 - \frac{dH}{H})3/2} \left\{ \frac{800{,}000 \times H.P. \times T}{n^2 \times w r^2} \right\}$$

$$\therefore s_3 = \frac{T \times C}{(w e^2)}$$ when c is a quantity varying with the percentage of load thrown on. Working out the values of c for $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and full load thrown on we get:

$c_1 = 292$
$c_2 = 790$
$c_3 = 1{,}195$
$c_4 = 1{,}790$

Therefore, we have the whole range of speed changes represented by the formula $(w e^2) = \frac{T \times C}{s}$ in which T represents time of governor for complete stroke, c is a quantity varying with percentage of load thrown on, and $(w e^2)$ represents moment of inertia of rotating parts of the unit.

First, let us plot the values of c for different amounts of horse-power thrown on from one-quarter to full load, using as ordinates the values of c and as abscisses, values of horse-power. This gives us the curve shown on chart.

The values of c must now be multiplied by the assumed values of T. For the conditions of the assumed example T will vary from 1 second to 4 seconds for good commercial operation, and may be any value between, subject to the choice of the designer and the manufacturer. To multiply values of c by T, plot a series of radiating lines making these lines stand for governor times and converging to a point on the zero line of the curve just drawn. These lines must be so drawn that the tangents of the angles they make with the vertical will be proportional to the times they represent. The results of this multiplication will be read on some horizontal axis, and they must next be divided by the assumed values of s_3. Choose a point of convergence for the speed variation lines and this must be located on the vertical line passing through the T centre. The allowable speed variation for commercial operation will not be over 25%. Therefore, from the point of convergence we must draw 25 lines, such that the tangents of the angles they make with the horizontal will be proportional to 1, 2, 3, etc., up to 25.

To determine the limits within which the desired results of $(w r^2)$ must fall, by working out a few cases we find that 0 to 50,000 will cover all the practical field of operation. Choose a scale such that these can easily be read; say, 5,000 equals 2 spaces. Therefore, we locate the centre for the speed variation lines on the vertical line which passes through the centre of the T lines, and 20 spaces above it. From this centre draw the radiating speed variation lines, according to the tangents of the angles.

To read the chart, enter at the bottom at the assumed load thrown on, and run up to the curve; from there go horizontally to the desired governor time, then vertically to the speed variation line, and then horizontally to the vertical scale representing value of $(w r^2)$. Or if value of $(w r^2)$, amount of load thrown on, and time of governor are known, enter as before at the load thrown on, run vertically to curve, thence to governor time and the intersection of the vertical through this point with the horizontal drawn from the desired value of $(w r^2)$ will be on or near one of the speed variation lines, thus giving the speed variation for the assumed condition.

AMERICAN GOOD ROADS CONGRESS.

Among the educational features to be presented at the American Good Roads Congress, at the International Amphitheatre, Chicago, December 14th to 18th, inclusive, will be a model boulevard, twenty feet wide and more than four hundred feet long extending around the arena. The boulevard will be divided into sections, each of which will be built of different materials or by different methods, so that practically every modern standard type of road and street construction will be shown.

In addition to the exhibits of several States and cities, a number of universities and colleges have signified their intention of presenting the exhibits which they have assembled in connection with their courses in Highway Engineering.

Work on the programme is progressing as rapidly as the circumstances will permit. The leading road-builders of the United States and Canada have consented to prepare papers or participate in the discussion on the phases of the subject on which they are best posted. This insures the presentation of all the latest developments in the lines of road organization, construction and maintenance. It also assures the wider and more comprehensive educational value of the proceedings.

INTERCOLONIAL RAILWAY BRIDGE OVER THE NASHWAAK RIVER, N.B.

The substructure work in connection with the bridge of the Intercolonial Railway over the Nashwaak River, and consisting of two abutments and four piers, has been completed by Baird and Howie, of Fredericton, N.B. The greater part of the concrete work on the piers and abutments was run last winter under severe weather conditions with no detrimental effect. Foundation work of a difficult character was encountered in some instances, one of the piers reaching 30 ft. below water level, below which again excavation to bed-rock was necessary.

The cost of the substructure will be approximately $45,000.

WORK FOR UNEMPLOYED AT BURNABY, B.C.

It is proposed in the municipality of Burnaby to set men to work under the supervision of Mr. Fred. L. Macpherson, municipal engineer, on the cutting of trees and the general cleaning up of road allowances throughout the municipality. A rock-crushing plant will also be installed. Crushed rock and cordwood are materials for which there has been a keen demand. The former has been subject to haulage from Pitt Lake.

The municipality is going ahead with all needed improvements and an extensive program has been arranged to provide employment throughout the winter.

STATISTICAL CONTROL OF RAILWAY OPERATION.*

By W. M. Baxter,
General Manager's Staff, Canadian Pacific Railway.

THE business of a railroad may be divided into two distinct departments, namely, acquiring traffic and moving traffic, which is similar in industrial enterprises to the selling end and the manufacturing end. A railroad manufactures and sells transportation.

The great difference between the producing of the railroad's commodity and that of a flour mill, or coal mine, from the viewpoint of management, is in the fact that the plant and equipment of the railroad is dissipated or spread over a large stretch of territory or country, while that of the flour mill or coal mine is concentrated, so that all supervision must be delegated, most of the work being done by transportation units, which are continually changing their location, so that they cannot be supervised except in a scattered manner.

An unusually large number of employees must work without supervision, and the margin of operating profit is exceedingly small, when compared to the average returns on the investments in manufacturing and farming.

As the general manager usually spends the larger portion of his time in inspection, and under normal conditions seldom directs the movements of trains, he sees but an infinitesimal volume of the company's business moved. As the scope of his vision is thus limited, other methods must be resorted to in order to check the operation. The means of accomplishing this is to separate the operation of the road into rigid and definite units and then to compare these units with similar ones on other roads, or with the same road at various periods, or with arbitrary standards chosen as guides, or bench-marks.

Controlling a railroad by means of statistics might be defined as the process of determining the unit in each operation and then maintaining these units as nearly rigid as possible, seeing that they are collected, reported accurately and promptly.

The basic operating unit in freight traffic is the ton-mile, which is the product of the ton and the distance. The basic unit in passenger traffic is the passenger mile.

There are 6 important statistical units deducible from these two fundamentals, which are defined as follows:—

1. The average train load, either freight or passengers, is obtained by dividing ton mileage and passenger mileage by train mileage.

2. The average car load, freight and passenger, obtained by dividing ton mileage and passenger mileage by the respective car mileage.

3. The average length of haul for passengers and freight, respectively, obtained by dividing passenger mileage and ton mileage by the total number of passengers carried and the total tons moved.

4. Ton miles per engine hour obtained by dividing the engine ton miles by the number of hours the engines are in service.

5. The average revenue per passenger mile and per ton mile, obtained by dividing the freight receipts by ton miles and passenger receipts by passenger miles.

6. The average density of traffic per mile of road, obtained by dividing ton miles and passenger miles by the length of road.

It is unfortunate that this data cannot be given to the executives earlier than 5 or 6 weeks after the operations have occurred, owing to the enormous concentration and calculations which must be resorted to in arriving at them on a large system economically. While they are of final value in determining the general efficiency of the system, it is necessary to have a more immediate check in the form of current records.

Perhaps the most tangible source of daily information is the train sheet, which is received by the train masters and superintendents, from the despatchers. This sheet records the movements of all trains on the division, showing their consist as to loads and empties and number of cars in the train, and sometimes shows the number of passengers carried on each of the passenger trains, as well as the general movements of traffic, the observance of schedule time, the cause of delays and weather conditions.

By this means of concentrating upon a number of primary officers as much first-hand detail information as they can absorb, the foundation of statistical control has been laid.

The results of these primary officers' observations are collected and passed on to their next superior, who receives similar reports from many such primary officers, and in this way the operations of the road and work performed is reported with diminishing detail, until the chief executive is reached.

The division superintendent is undoubtedly the most important primary officer. The operation of his territory is reported to him daily, and frequently on congested terminals he receives certain information hourly. In addition to this daily data, he has a number of statistical sheets prepared monthly, which show in condensed form, sometimes grapically, the comparative results of a large number of operations on a division, one month as against another, one day as against another, and one year as against another.

When these records are graphically presented the sheets are ruled with a number of vertical lines, representing the number of days in a month, or the months in a year, or, in other words, progress of time, while a horizontal ruling to scale represents volume or quantity.

In this way the directing officer can readily see, for example, what has been the average tons per train mile, and the average pounds of coal consumed per 1,000 ton miles for a certain district or territory for a number of months, compared with the same months of the previous year, or if the records have been kept for a number of years, fair indication will be had of the season's effect on the traffic.

The important daily returns which a superintendent receives are those showing the number of trains of loaded cars, empty cars, and total cars received and forwarded in each direction at all of the terminals, also this same information for train movements at important intermediate points. He must know the entire train movement and the tonnage movement, and the failure to perform a given service of these movements as expressed in delays and other causes, must be thoroughly investigated and remedies applied. He is informed about the conditions of each of the yards and terminals on his division, and also about outside important terminals, which may affect movements in his territory. He knows the demand for freight and passenger equipment and the class of each required at the various points, as well as the available supply, and the condition and amount of power to move it. All of this information is of a statistical nature.

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* From a paper read before the Canadian Railway Club, Montreal, Sept. 8th, 1914.

The officer next superior in rank is the general superintendent. He has received through the superintendents statements showing by divisions the number of engines assigned, total number of through engines shown on the train sheets, the number of through freight engines out of a shop and available for service before a specified time, usually at midnight, the number of through freight engines in shop for repairs and reported as coming out within 24 hours, and those which will not be completed in 24 hours, and also the average mileage made by these engines in service, special engine assignments, such as way freights, passenger engines, switch engines, work trains pick-ups, etc., together with general remarks on the entire power situation.

He also receives reports on the cars handled at stations, showing the number of cars of merchandise on hand and when unloaded, together with information relating to special car movements. He is also notified concerning traffic exchange at all foreign line connections, and if there is a special traffic, originating in his territory, such as coal mining, or some big manufacturing industry, he is advised of the number of cars moved and supplied, and a statement of detentions and their causes, as well as a report on the weather. While these are the principal reports he receives there are numerous special and minor statements furnished or compiled in his office daily, weekly, and monthly, which are beyond the scope of this article.

It is evident that no general superintendent could exercise close watchfulness over the thousands of separate items which these reports cover, and in reality he does not. A man in this position not trained on the property could not make efficient use of them, as the information gained is not so much absolute as relative. As the great majority of the data he thus receives must be judged comparatively to be of use, the graphic method of recording statistics is perhaps most practical and is instantly read.

The general superintendent, being familiar with all the conditions of his territory and knowing how it ought to operate, can look for the deviations from the results he is expecting. It may be fairly said that his system of control is by deviations from known standards.

The general manager, however, receives a smaller number of reports dealing only with the principal topics. All of these general considerations, and many other local ones, the managing executives have clearly in their minds, but accurate statistical information must be the basis of their judgment in any specific case. They must receive constant advices relative to the current productive power of various localities on the system, the state of the wheat crop, the cotton crop, the lumber market, or seaport traffic, so as to be able to foresee the possible future requirements necessary to handle the business expeditiously. This is again a matter of statistical organization, but it can be made to yield large results in actual operating efficiency.

The traffic department and the operating department must work hand-in-hand in their investigation of anticipated business, although from different motives.

The traffic manager is interested primarily in car supply and train service. It is his duty to secure the largest possible number of routings of business actually in sight, and also devise means for creating business that is not in sight. His business is divided into two main classifications, local traffic and competitive traffic, and he requires daily statistics to show how his local traffic compares with his expectations or with other seasons, and it is of great importance to him to know how his local agents are handling the competitive situation.

Even the local traffic is probably competitive with the traffic of other roads serving other markets, and the traffic manager must gauge the prosperity of his local industries largely in terms of their output, and this can be done only by comparative statistical data.

The intricacies of the mechanical department are, perhaps, most susceptible to statistical control. It deals with plain units in great variety, as, for example, pounds of coal consumed per specified service as per train mile or ton mile, or engine miles between stoppings or axle miles per hot box. There are really myriads of details in the mechanical performance of cars and locomotives, which can be standardized by means of statistical records. And deviations from these selected or normal standards will show up in great contrast, thus plainly denoting where investigation and remedy is needed.

The superintendent of motive power and his primary officers are continually engaged in these investigations.

Statistics of earnings and expenses are the ultimate check on all of the road's records, and when taken in conjunction with the statement of work performed and shown graphically, present the final picture of the system.

Without knowledge of the work done, however, earnings and expenses are not an adequate means of control. Many roads west of the Mississippi River in the United States operate for 60 per cent. of gross earnings, or slightly less, while in the East the average is nearer 70 per cent. Thus the operating ratio is an uncertain test of efficiency. The high rates in the newly-settled parts of the country make relatively easy a showing which the best operation in the world could not accomplish in a territory of intense competition of long duration, where the struggle for business has reduced the margin of profit of the railroad to a minimum.

These comments apply primarily, of course, to the statistical use of the operating ratio by the banker or broker, or student of railway affairs who is trying to judge one property in terms of another. The manager of the road confronted habitually by the same set of conditions can form a great many accurate opinions from the reported earnings, and they are of the highest statistical importance to him. Where detail knowledge of the property is absent, however, there could scarcely be a more perilous standard of railway efficiency than the relation which operating expenses bear to earnings. A road in mountainous country must pay relatively high sums for every ton moved, because of the necessity of double heading or of breaking up trains into short sections. On the other hand, a road operating in a swampy, water-level territory, as some of the roads in the Mississippi Valley do, are likely to have an abnormal maintenance cost. A road hauling large proportions of merchandise will have a high ton mile rate, but also a high ton mile cost, because of the necessity of rapid service and small tonnage in car loading. A railroad operating in the cotton belt, or wheat belt, will fluctuate greatly from one season to another, while a road in Canada will report a marked increase in operating cost during winter months.

Similar difficulties confront the banker and broker in making comparisons of efficiency based on the ton-mile. When 1,000 tons are moved 100 miles, a service of 100,000 ton-miles has been performed, regardless of the nature of the commodity. Some of the railroads in Indiana and Illinois, built to haul coal, frequently produce 100,000 ton-miles by moving a 4,000-ton train 25 miles, with a single engine and train crew. On the other hand, a road loading light manufactured articles might be doing

well to load three tons per car, and in this instance it would take a single train moving approximately 1,000 miles, or 40 trains moving each 25 miles, to produce 100,000 ton-miles.

The worst of it from a statistical point of view is that most railways are moving a thousand different kinds of traffic all at the same time, and cannot always manage even to haul their coal and light manufactured articles in separate trains. The ton-mile in consequence is an average figure composed of a multitude of dissimilar parts.

This, however, does not confuse the general manager or his assistant. They have been watching the operations of each of the districts for years, and if a new superintendent on a division increases the average loading from 690 to 720 tons, they regard it as a measure of increased efficiency, because they are comparing the results of a known territory at a particular season, under known circumstances with the same territory, and circumstances in another season.

Even this discriminating use of the ton-mile, when expressed in terms of average train load, often leads to its own peculiar form of error. When traffic is handled smoothly at efficient speeds, big train loads almost always mean economical operations, because they indicate that the business is being done with the fewest locomotives and train crews. But, if freight is held at terminal points longer than competitors are holding it, in order to collect maximum loading, or if the tonnage ratings are pushed to the limit, with resulting engine failures, blockaded traffic, overtime for crews and abnormal coal consumption, the big train load results in expensive economy.

This example of an over-done economy is likely charged to statistical government, but it illustrates a point. Statistics are only of use comparatively when measured against similar performances elsewhere, or against a standard arbitrarily chosen and designed in advance. But the analogy must be a real one. It is useless to compare results obtained with dissimilar commodities, or with the same commodities handled under different conditions of grade, curvature, and motive power.

UTILIZING ONTARIO'S WATER POWERS.

The mines and metallurgical plants of northern Ontario are now for the most part operated by electricity generated by water powers. At Cobalt, the falls and rapids on the Montreal and Matabitchewan Rivers are utilized; at Sudbury, mines and smelters are supplied with power by the Spanish, Wahnapitae and Vermilion Rivers; power is conducted to Porcupine from the Mattagami; at Michipicoten the Michipicoten and Magpie hoist the ore and operate the machinery at the Helen and Magpie mines; the Canadian Exploration Company's gold mine at Long Lake, also utilizes water power. A new water power installation is being put in at Gowganda Lake to operate the Miller Lake-O'Brien silver mine and a transmission line is under construction from the Blanche river at Charlton to work the gold properties in the new field at Kirkland Lake. Water powers are numerous in northern Ontario, and, as at Iroquois Falls on the Abitibi River, are employed also to operate pulp and paper mills. They have been of great service to the mining industry in providing cheap power.

The Argentine Minister of the Interior has under consideration a project to establish a motor omnibus service in the national territories of Argentina. It is proposed to initiate a service in the tobacco-growing districts of San Javier and Tacaruare in the territory of Misiones, where tobacco cultivators frequently suffer losses because of lack of transportation facilities.

ROAD WORK IN SASKATCHEWAN.

Good progress is being made on road construction in Saskatchewan, according to an announcement made by F. J. Robinson, chairman of the Highway Commission in Regina. He stated that more than 1,500 men and 1,000 teams were now at work on road construction. It is expected that the number of men employed on this class of work will be greatly increased within the course of another week.

Of a total sum of $1,200,000, voted by the Saskatchewan Government for highways improvements, $1,002,-685.84 was spent on the roads during the year ending April 30, 1914, according to the annual report of the Saskatchewan Highways Commission, tabled in the House a few days ago. Of this sum $507,517.02 was spent on road improvement direct and $417,065.69 was spent by municipalities under commission regulations. For steel bridges and concrete abutments there was a vote of $300,000, the total sum spent on this class of construction being $337,483.18.

At the recent session of the Saskatchewan Legislature it was announced by Premier Scott that the provincial government has decided to spend $750,000 instead of $500,000 as originally intended, on roads in the southwestern part of the province. Here the farmers are dually handicapped by long hauls to market and over extremely poor roads.

THE EMPRESS-BASSANO BRANCH OF THE C.P.R.

A very important line now under construction by the Canadian Pacific Railway Co. lies between Empress and Bassano, Alta., and has just been opened to service. It forms a part of the double-tracking scheme, and is considered by the company an important link in the Transcontinental route, as it reduces the distance between Swift Current and Bassano by 25 miles, and avoids some very heavy grades which exist on the line through Medicine Hat. The new line has been provided with 85-lb. Algoma steel rails. At an early date all the transcontinental trains of the C.P.R. will be routed over it.

It is proposed to make a further reduction in the mileage from coast to coast by a new line between Cabri and Moose Jaw, as well as to avoid some heavy grades thereby.

ELECTRIFICATION OF THE LONDON AND PORT STANLEY RAILWAY.

The work of renovating this line, preparatory to its electrification by the London Railway Commission, is progressing rapidly, a good portion being completed. The whole line is being reballasted by the Pere Marquette Road, which is still operating it. The steel on the main line, with the exception of around the switches at the terminals, has been renewed with 80 lb. rails, Canadian Northern Section; and the ties are being replaced with new untreated cedar ties. The following contracts were made: Algoma Steel Co., 3,000 tons of rails and angle bars, 30,000 tie plates; J. J. Gartshore, 380,000 spikes; Canadian Ramapo Iron Works, 52 sets of switches and frogs; Steel Co. of Canada, 34,000 track bolts and 65,000 tie plates; and Canadian Concrete Products Co., 1,100 ft. of concrete piping of various sizes. The inspection of most of the material was made by R. W. Hunt and Co.

Specifications are nearing completion for the electrification of the line, including sub-stations, overhead construction, bonding, cars and locomotives. Terminal plans are also being considered. The engineering work is all being handled by the engineering staff of the Hydro-Electric Power Commission of Ontario, for which F. A. Gaby is chief engineer.

AT WHAT PRICE IS POWER CHEAP?

By H. E. M. Kensit, M.I.E.E.

CHEAP power is one of the principal topics of conversation from coast to coast in Canada; cities that have it, or think they have it, spend thousands in advertising it, and those that have it not are eager to spend a million or two on any scheme that appears to offer it.

Yet, it is safe to say that the great majority of people who talk glibly on the subject have no clear idea as to what constitutes cheap power nor of whether power at a given price would be cheap for a given purpose; in fact, the general idea appears to be that if power at a certain price is "cheap" for any purpose it is therefore cheap for all purposes.

If the following questions were put to any but experts on the subject the replies would, in about nine cases out of ten, be as shown:

(1) Is power cheap at $25 per h.p. year? Yes.

(2) Is power cheap at 6 cents per kw.h.? No.

(3) Is power at $25 per h.p. year cheaper than at 6 cents per kw.h.? Yes.

But, as a matter of fact, the answer given is just as likely to be wrong as right, depending entirely on the circumstances of the individual case for which the power is to be used.

To demonstrate this, it is only necessary to analyse the accounts of a few miscellaneous users of power. The following is condensed from the actual accounts by meter of consumers supplied under a sliding tariff ranging from 6 cents per kw.h. for consumers taking less than 100 kw. per month to 2 cents per kw.h. for users taking over 8,000 kw.h. per month, with a fixed charge of $1 per month per rated h.p. of motors installed. The equivalent cost per h.p. year is the total annual account divided by the rated h.p. of motors installed and connected (column 3). Column 5 is the rated h.p. at $25 per h.p. divided by the kw.h. actually used.

The fact that the actual cost exceeds 6 cents in some cases is due to the fixed charge of $1 per month per rated h.p. having a large influence where the consumption is small.

Going back, now, to the questions given above and taking them in the same order:

(1) Is power cheap at $25 per h.p. year? It will be seen from column 3 that in 8 out of the above 13 cases it would not be cheap and in some of them it would be very expensive. In case 7 it would be equivalent to 44 cents per kw.h.

(2) Is power cheap at 6 cents per kw.h.? It will be seen from columns 2 and 4 that in 5 cases it would have been decidedly cheap, equivalent to from $3.40 to $15.40 per h.p. year.

(3) Is power at $25 per h.p. year cheaper than at 6 cents per kw.h.? It will be seen from column 5 that in 9 cases it would have been cheaper and in 4 cases (45%) it would have been dearer.

Most people, including engineers, will declare unhesitatingly that 6 cents per kw.h. is too dear for power, but that $25 per h.p. year is cheap power. Yet, here are 45% of actual cases in a list of 13 miscellaneous industries in which 6 cents per kw.h. works out cheaper than $25 per h.p. year, and in one case works out to $3.40 per h.p. year. In fact, the table shows that for small industries with poor load factors 6 cents is quite a cheap rate.

On the other hand, even a two-cent rate on an 80% load factor, such as might be obtained in pulp mills, cement works, electro-chemical works, etc., works out at 88% motor efficiency to about $120 per h.p. year.

Referring again to the table, it will be seen that a sliding tariff of 2 to 6 cents, such as could be given by any ordinary steam power station, works out in practice to a very reasonable cost for power supply to a miscellaneous list of industries, the only exception in the list being an hotel and not a factory.

Comparative Cost of Power for Small Industries, Per K.W.H. Actual and Per H.P. Year Calculated.

		1	2	3	4	5
	Class of work.	Rated h.p. of motors.	Actual cost per kw.h.	Equivalent cost per h.p. year.	Rate per h.p. year equivalent to 6 cents.	$25 per h.p. year would have been equivalent to:
1.	Foundry	13½	5.79 cents	$14.70	$15.30	9.85 cents
2.	Brewery	33¼	3.63 "	19.60	32.40	4.62 "
3.	Printing	11½	7.63 "	41.20	32.40	4.63 "
4.	Printing	11	5.27 "	26.70	30.40	4.94 "
5.	Printing	5	7.15 "	12.00	10.00	14.80 "
6.	Brickyard ...	35	3.34 "	6.33	11.40	13.20 "
7.	Planing mill..	77½	5.44 "	3.08	3.40	44.20 "
8.	Planing mill..	5	5.72 "	30.90	32.40	4.63 "
9.	Cold storage..	43	2.91 "	14.70	30.30	4.95 "
10.	Laundry	30	3.01 "	27.50	54.80	2.74 "
11.	Flour mill....	75	2.25 "	21.80	58.00	2.58 "
12.	Hotel	5	4.73 "	106.40	135.00	1.11 "
13.	Elevator	15	9.10 "	8.00	5.27	2.84 "

NEW FRASER RIVER CHANNEL.

Fraser River shipping will receive an enormous impetus upon the opening of the new channel, which has been in the process of construction during the past summer. This channel provides from 18 ft. to 20 ft. of water at low tide. It lies about half a mile north of the main waterway, which has been a menace to the shipping interests of the Fraser River towns owing to the continual formation of sandbars in the channel. The new waterway will be ready for use as soon as the necessary aids to navigation have been placed.

Editorial

A SLACK TIME FOR ENGINEERS.

An example more illustrative than that which has brought about present conditions, of the setbacks that the practice of engineering may experience would be hard to find. Engineering, as the term is used in its most familiar sense in Canada, cannot be said to include in its various branches many of the same that have been spurred on to working double shifts as a direct result of the European crisis. As a general thing the opposite exists, and half time, or less, prevails. Sherman may not have had engineering prominently in mind at the time, but what he said applies, nevertheless.

The Canadian Engineer has received assurances from the Federal Government, from various departments of the Provincial Governments, from numerous industrial, and from a few municipal bodies, that the war is not causing a material cessation of present undertakings, small or large, and that all engineering work that can possibly be continued will not be interrupted. It is very obvious, nevertheless, from the numbers of engineers with little or nothing to do, that the former assertion does not universally apply, while the latter gives little assurance for the future even to many who are still the proud possessors of work in hand. It all emphasizes the dependency of the present-day engineer upon financial interests over which he has little or no control. It is a fact that no other learned profession is suffering so acutely from the present condition of affairs and the lesson is profoundly brought home that, while it is no disgrace at all for a good and capable engineer to be at present out of a job, there is at all times room for a broader aspect on his part, when judged in conjunction with the execution of the material duties upon which mankind depends. For the past 10,000 years or more the engineer has been doing the important things in the improvement of civilization, and the time is about ripe for him to have a little more to say in connection with their administration. This has been the feeling oft repeated by *The Canadian Engineer*. Adherence to the old definition of the engineer might well be more concrete. Or, the following definition advanced by Parsons in his "The Philosophy of Engineering" might be applied with better advantage to the new engineer as he should be found in the 20th century: "The man of commerce, industry, business, who makes engineering a means rather than an end—the man of affairs." Although the above is faintly apropos of the present circumstances in engineering work, it is well for each engineer to weigh carefully the soundness of his method of conducting his business. Many have now time to do it. Engineering is business and there should be better business methods in engineering.

As for a pronounced revival, in the near future, of engineering activity, it is useless to predict. There are, however, frequent instances where engineering services are to be required and it is wise for the engineer to devise and employ suitable means of keeping in continuous touch with these new developments, though they may seem few when compared with the constructional activities of the past few years. The Construction News section of this journal, for instance, is a medium which reports weekly what undertakings of note are about to be entered upon or proposed throughout the Dominion. It would be surprising to many of our readers, perhaps, to learn what advantages are derived therefrom by the many who have learned its value and follow it closely. The impression entertained by some is incorrect as to its items being of use only to engineering and industrial corporations. The engineer out of employment might well apply what it offers to his own needs, and with material benefit; it displays to him an additional service of which he may not have availed himself heretofore, to wit, a list of opportunities—and opportunities appear to be what many are most interested in just now. We are not unintentionally encroaching upon the field of this journal's circulation department in expressing our belief that *The Canadian Engineer* can be of distinct service to the unemployed. Apart from its other services, it is able to afford a channel of access to employment, at this stage when employment bureaus, our own included, are choked at one end with applications for work, and are food for the ivy green at the other.

This is a time when the engineer must be more systematic and persevering than ever in keeping in touch with what is going on. Emerson's man in the depth of the forest, whose ability in some line of work would compel the world to wear a road through the wilderness to find him, has no place among conditions as they are.

THE ENGINEERING STUDENT AND THE CRISIS.

In our universities and colleges an atmosphere pervades, the like of which has never been known to Canadians of the present day. It is the atmosphere of war, and it has associated with it evidences of loyalty of which we might well be proud, even if the Canadian coasts formed a prominent part of the setting of the great European struggle. The circumstances clustered around the cause for which Britain is so staunchly contending may or may not be clearly understood by all our young men, but the justness of her stand is not for a moment being made a topic for deliberation. Every step toward military training adopted by our engineering schools, relieves but momentarily the pressure from behind, owing to the students' eagerness to uphold her principles.

Through it all, however, the importance of the investment which he is making in an engineering training must not be lost sight of by the student. The dividends therefrom should be regarded by him as the future source of his daily bread, or, if he does not deign to consider them as such, engineering is to be, at least, the prominent part of his life's work. The state of war, though it may be more immediate at present, is momentary compared with his engineering career. The former may demand his services in the field for a short period of time or not at all. The latter will surely demand his services throughout the remainder of his efficient lifetime.

With this in view, then, the engineering course must not be forced into the background. After graduation he will deal in a professional way with the public and with public officials. In this capacity he may become an exemplar in the application of his training to public service; or, he may drift along "without giving offence to anybody and without accomplishing anything progressive." It depends upon him and the benefit he derives from his

technical course. He must strive toward usefulness to his country in peace as well as in war.

This will entail greater effort on his part at the present time. His military study will encroach upon the time intended by him for sport and pastime and to a degree perhaps, upon his time for academic work. But it remains for him to make his training his business, and to adhere to the Empire's slogan, "Business as usual."

ENLARGEMENT OF THE LACHINE CANAL.

The Department of Railways and Canals has completed the widening of the Lachine Canal above Cote St. Paul, thereby removing a difficult curve and effecting a decided aid to navigation. The work has been under way since last March and only a few scattered jobs remain unfinished. Before the opening of navigation last spring the necessary length of the canal was dewatered and concrete construction brought up above water-level at the Cote St. Paul lock. This was completed without interfering in any way with navigation. Excavation work was then commenced and during the summer the narrow curve approaching the lock has been converted into a wide basin.

COST OF OILING STREETS AT FORT WILLIAM.

A report presented last week at a meeting of the Board of Works, Fort William, presents some interesting figures on the cost of oiling streets, compared with the cost of watering. The streets were oiled three times during the past season, these three oilings having been found sufficient to keep the dust nuisance in check throughout the whole summer, and it is thought that next year the same streets will only need one or two applications, thereby furthering the reduction in cost.

The cost per foot frontage for oiling amounted to 5.7 cents, or 1.9 cents per foot frontage per operation. The corresponding cost per foot frontage for watering these streets regularly day after day was 5.6 cents. Moreover, as stated in the report, the latter method of settling the dust during hot weather was efficient only for an hour or so. In view of the above results the Board of Works has recommended the installation of a storage tank to provide a larger capacity for oiling streets in future.

The hydro radial project is meeting with favorable reception. Eleven out of thirteen municipalities in the counties of York and Ontario carried municipal by-laws on Monday, authorizing the signing of contracts.

DON SECTION, BLOOR STREET VIADUCT.

THE accompanying illustration is a view of one of the alternative designs submitted in connection with tenders for the Don section of the Bloor Street viaduct. It will be remembered that tenders for this section were advertised for late in July, to close October 5th. This date was later extended to October 13th. At that time eleven tenders were in the hands of the Board of Control. One, however, was irregular, while another one referred only to the superstructure. The nine valid tenders, five of which were for concrete and four for steel structures, were referred to Mr. R. C. Harris, Commissioner of Works, for a report.

The following is a list of the tenders and prices:

For Steel—

(1) Quinlan & ~~Robinson~~, Montreal ....$ 996,564.81
(2) Wells & Gray, Toronto 1,009,760.75
(3) Navin Bros., Moose Jaw 1,316,954.12
(4) Sherwood & Sherwood, Toronto ... 1,353,074.91

For Concrete—

(1) Jones & Girouard, Ottawa ....$ 849,055.35
(2) Barzaghi-Vought Co., New York .. 875,000.00
(3) Daniel B. Luten, Indianapolis, Ind. 1,098,781.82
(4) C. E. Deakin & Co., Toronto 1,125,000.00
(5) Jas. Cowlin & Sons, Montreal 1,249,701.00

Of the steel tenders, the first two are stated to be based on designs prepared by the Canadian Bridge Co., Walkerville, Ont., and the remaining two on designs of the Dominion Bridge Co., Montreal.

Of the alternative designs in concrete tenders No. 1, 2 and 4 are understood to be based on a design prepared by ~~James~~ Jones, Loudon & Hertzberg, consulting engineers, Toronto, (illustrated herewith). The third tender is based on Mr. Luten's own design, while we are informed that the fifth is an English design.

At the time of writing no award has been made. It is expected that the Commissioner's report will be in the hands of the City Council next week.

Alternative Design in Concrete for Bloor Street Viaduct (Don Section).

THE RELATIVE VALUE OF DIFFERENT PAVING MATERIALS.

In considering the different kinds of material it is necessary first to establish a standard for a perfect pavement and study its different properties. A perfect pavement should be cheap, durable, easily cleaned, present light resistance to traffic, be not slippery, be easily maintained, favorable to travel, and sanitary. Admitting that a perfect pavement should have these properties, it must be understood that they are not all of the same importance and, therefore, a discussion of these properties is enlightening.

In a paper read by Geo. W. Tillson, consulting engineer, New York City, before the Cleveland Engineering Society the author assigns a percentage value to each type, assuming that a perfect pavement has a value of 100. Following are portions of his paper.

Cheapness.—It may be said that cheapness is not a physical characteristic of any material. While this is undoubtedly true, at the same time it must be admitted that it is an important factor in the selection of a material. It matters not how good or how adaptable any material may be, unless the authorities have money enough to use it, it is not available. So that cost must be considered as much in the examination as it would be by a private individual if he were about to purchase any article for himself. The question then resolves itself into what is the best that can be obtained for the money at hand. Cheapness, therefore, is given a value of 15.

Durability.—This is an economic and an important factor. It depends, however, upon a great many conditions. There are some materials which have a certain life only, no matter what the traffic, because they will be destroyed by the action of the atmosphere. This is true of asphalt and untreated wood, and treated wood to a certain extent. With stone, brick and such materials the durability depends almost entirely upon the amount and character of the traffic. The influence of traffic, however, is governed by several conditions, *viz.*, the width of roadway, character of the pavement, presence or absence of street car tracks, state of repair, and how well the pavement is cleaned.

It can be easily understood that the width of the roadway is an important factor, although of course traffic should be measured by the tonnage per foot or yard of width. This, however, must be somewhat modified, as in a narrow roadway the traffic both ways is confined almost to the same lines, so that the wear will be greater for the same amount of traffic than if the roadway were wider, permitting vehicles to move freely in the portion of the roadway assigned to their use.

By character of pavement is meant the detailed method used in laying the different materials; for instance, if a block pavement is used, the character of the foundation, joint filling and method of laying; asphalt pavement, according to the mixtures; and wood pavement, whether the same is treated or not and the method of laying.

The presence of car tracks on a street makes a material difference in its life, for the reason that the traffic is confined almost to one line on each side of the track. In a report to the City of Buffalo, where careful records have been kept of the life of asphalt pavements, it is stated that the presence of street car tracks will diminish the life of the pavement two years.

Whether or not a street is kept in good condition makes a great difference in the life of the pavement. The old proverb, "A stitch in time saves nine," applies undoubtedly to street pavements as forcibly as to any other class of construction. If a pavement be kept smooth so that traffic can be brought upon it perpendicularly, the wear will be reduced to a minimum. If, however, the pavement is allowed to be rough so that the wheels of vehicles strike it irregularly and with abnormal force, the wear is much greater than it should be. While this is particularly true of a block pavement it applies to a certain extent to sheet pavements.

The effect of street refuse on a pavement depends entirely upon the character of the pavement itself. If it be of asphalt, and the refuse is damp or moist to a considerable extent, it will have an injurious effect upon the surface. If, on the other hand, the pavement be of stone or brick, the refuse on the pavement will reduce the wear from traffic and not injuriously affect the material itself. This question, however, is not as important as it was some years ago, as all cities recognize the necessity of keeping pavements clean. Taking all things into consideration, durability is given a value of 21.

Easiness of Cleaning.—This is an economic factor, although the state of cleanliness of a pavement has a bearing upon its sanitary influence, so that the degree to which a pavement can be cleared by ordinary appliances and without undue expense is important. For that reason a value of 15 is given easiness of cleaning.

Resistance to Traffic.—This is an exceedingly important consideration. Street pavements are constructed primarily for the transportation of vehicles throughout the city, and anything that will reduce the traction required to move the loads is highly important. This property, therefore, has been given a value of 15.

Non-Slipperiness.—The slipperiness of a pavement depends upon its material and detailed construction, also its condition. The efficiency of a horse varies with its foothold. It does not matter so much what his strength is, if he cannot apply it to the best advantage. Any material that will allow him to do this has a particular value. It is varied to a great extent by the condition of the pavement; for instance, the presence of sleet or snow. Taking all matters into consideration, non-slipperiness is assigned a value of 7.

Maintenance.—The maintenance of a pavement is closely allied to first cost, and in considering the entire cost of a pavement the expense of maintenance is an important factor. This of course depends not only upon the character of the material itself, but also upon the traffic the street receives. It is unquestionably a fact that a certain amount of traffic is beneficial to wood or asphalt pavements, as it keeps the upper surface of the pavement dense and to a certain extent impervious to water, while as has been said before the imperishable materials wear in accordance with the amount of traffic. This property has been assigned a value of 10.

Favorableness to Travel.—By favorableness to travel is meant the ease and comfort which are enjoyed by driving over a smooth pavement and also the decrease in wear and tear on vehicles on a smooth pavement as compared with one that is rough and uneven. The first of these characteristics can be appreciated by anyone driving in the streets. While the wear and tear on vehicles cannot be exactly computed, information obtained from large department stores in Brooklyn shows that the changing of the old cobblestones of the borough into asphalt has very materially reduced their cost of repairs. In a paper read before the Institution of Civil Engineers in England in 1871 it was stated that the new pavements which had recently been constructed in Liverpool had made a saving of $50,000 per year for every mile of pavement on the dock lying streets, without counting the reduction to the

wear and tear on horses and vehicles. This property will be of more value and is receiving more attention on account of the introduction of automobiles and motor trucks. At the present time it is assigned a value of 5.

Sanitariness.—The sanitariness of pavements is increasing in importance from year to year as more attention is given to health conditions in our large cities, and the fact that certain pavements can be more thoroughly cleaned and that the material itself does not absorb moisture are not the only considerations. Schools and hospitals are increasing in number in all of our cities, and it is a recognized fact that as noiseless a pavement as possible is necessary in front of both. Not only that, but in the large office buildings where a great many clerks are employed from day to day the noise caused by heavy vehicles driven over a rough stone pavement has a disturbing effect upon their nerves. While this may seem a little extreme, it is an important consideration. This property, therefore, is rated at 13.

Having thus obtained a tentative standard for a perfect pavement, the different paving materials can be compared and in this way a value obtained for each material. Taking up, therefore, the materials that have been referred to as standard, the stone will be first considered.

Stone Pavements.—Granite and the harder sandstones are those that are principally used in the stone block pavements of this country. The particular kind to be used will depend upon the availability and cost. It would be foolish to consider granite as a material where it must be obtained at great expense and where a good sandstone is available. In this study, however, granite is considered, as it is a material that is used in New York City and one with which the author is most acquainted.

In this connection it should be stated that the figures arrived at in this study by the author must be varied in every locality and must vary to a great extent according to the judgment of each individual engineer. He wishes it understood, however, that he does not consider the exact figures as of so much importance as the method of obtaining the results. So that too much importance should not be given to the results shown.

The granite pavements of to-day are very much better than those that were laid even four or five years ago. It has been found that on account of their being laid on a concrete foundation it has been possible to reduce the depth of the blocks and make them of somewhat smaller size otherwise, thus rendering it possible to get a better cut block at the same expense as before and allowing the blocks to be laid with a closer joint, thus reducing abnormal wear.

The locks are laid on a sand cushion on a concrete base, the joints being filled with cement grout, tar and gravel, tar pitch alone, and sometimes a combination of pitch and sand. The author believes that with a small joint and a combination of good pitch and sand the best results will be produced. While a cement grout joint makes a smooth pavement, it is often difficult to close the street long enough to allow the cement to set, and it also makes a pavement that is exceedingly difficult to repair after it has been torn up for any substructure purpose.

In considering the value of different materials as applied to different streets it is assumed that an intelligent selection of the different materials has been made, as upon that will depend the results entirely. For instance, a granite pavement could be laid on a residence street with light traffic, where its durability would be long and the cost of maintenance practically nothing. On the other hand, an asphalt pavement could be laid upon a heavy business traffic street, where its life would be short and the cost of maintenance enormous. If, however, an intelligent selection of material is made for all streets of the city, what will be the natural life and cost of maintenance will be found.

In 1913 in the Borough of Brooklyn the granite pavements cost 3.9 cents and the Medina sandstones 6 mills per square yard, all on concrete.

Considering all the properties of a perfect pavement, and taking them up in detail, for granite pavements values have been given as shown in the accompanying table.

Wood Pavements.—Wood pavements have been laid at intervals in this country for some seventy years. The first pavements were not only of untreated wood, but of wood selected without much regard for its natural durability. The result was failure, as could have been expected. The repeated failures of the different kinds of wood, however, although they delayed, did not prevent entirely the establishment of wood in this country as a standard material. The success of the wood pavements in Europe made it positive that they could be laid successfully in this country under proper conditions.

The first treated wood pavement in this country was laid on Tremont Street, Boston, in 1900. This pavement has been in use during this entire period with very small repairs, and is in good condition at the present time. It is composed of blocks treated with a composition made up of one-half creosote oil and the other half resin. Pavements of this character were laid in New York and other cities, but on account of the increased price of resin it was dropped out of the mixture and creosote oil only used.

There has been a great deal of controversy as to the character of the creosote oil to be used for this purpose, the principal point being the specific gravity. The theory of mixing the resin with creosote was that, it being a more stable material, it would prevent the volatilization of the creosote and so preserve the blocks from decay for a greater length of time. The object of treating the wood is to prevent decay and also to make the blocks stable by preventing the absorption of water so that they will not shrink in dry weather or swell in wet and thus cause bulging. It was thought that by using a heavier oil this result could be obtained as well as by the use of a light oil with resin. The relative values of the heavy and light oils have never been determined, but the author has always been in favor of the heavier oil.

The present method of laying wood pavements in this country has not been in use long enough to determine what the cost of maintenance is, but figures obtained from St. Louis, Minneapolis and other cities indicate that it is exceedingly small. The first pavement of this character to be laid in Brooklyn was in 1902, and it has had practically no repairs for wear and tear since laid. It is, however, on a light traffic street. The total cost of maintenance of the wood pavements in Brooklyn in 1913 was 1.4 cents per square yard on pavements that had been in use from eight to eleven years. This cost, however, included, besides actual wear and tear, damage caused by openings in the pavement, although not the cost of repaving the openings themselves. In Paris in 1911 the cost of repairs was 26 cents per square yard. In London the average cost is 20 cents per square yard.

The fillings for joints in wood pavements are sand, asphalt or coal tar pitch, and cement grout. The practice in Brooklyn has been to fill the joints with sand, and first-class results have been obtained. Some people, however, prefer the bituminous and others the cement filler;

either will give good results when properly used, although the author does not look with much favor on the cement grout filler.

There is no question that wood block is an important paving material, and on streets where the traffic is heavy and noise is a great detriment it is most advisable. Its strongest point is its noiselessness and its weakest its slipperiness. It has been given a value as shown in the table.

Brick Pavements.—The first brick pavements in this country were laid in Wheeling, W. Va., in 1870, but the material did not come into general use for some time. Many failures have occurred in brick pavements because people did not understand the difference between bricks, and it was not easy in the early days of the industry to determine previous to its use whether a certain brick would or would not make a good pavement, and then it was not known what was the best method of laying. Both of these matters, however, have been fully threshed out, and, in the judgment of the author, this is mainly due to the work of the National Paving Brick Manufacturers' Association, which has maintained a paid secretary to look after the interests of the brick manufacturers, not simply to enable the manufacturers to sell their product, but that every city should get the best possible brick pavement obtainable.

With the present knowledge of the art of making brick and the methods of testing and laying, it is as possible to determine in advance what the results will be with brick as with any natural material.

It is conceded, of course, that brick pavements, like all others, must have a good foundation so that the question at issue, after the bricks themselves have been determined upon, is principally the cushion on the concrete and the character of the joint filling. The National Paving Brick Manufacturers' Association has always been very strong in advocating a 2-inch sand cushion laid upon the concrete. Most engineers in the east, however, believe that only 1 inch is necessary and that no more should be used, the idea being that all that is required is to have a sufficient quantity to allow the brick to be well bedded and have an even bearing over its whole surface. If, however, experience demonstrates that a 2-inch cushion is better than a 1-inch, the extra expense is negligible and it should be adopted.

Three kinds of joint filling have been used: sand, coal tar pitch, and cement grout. At the present time sand is not used to any great extent, as it is conceded that a material should be used that will protect as much as possible the corners of the bricks so that the wear may be in accordance with the principle previously laid down in this paper—as nearly vertical as possible.

The question of coal tar pitch and cement cannot be so easily dismissed, however. The advocates of both materials are very many and present strong arguments, and it must be admitted that good results have been obtained with both kinds of filling. The author believes, however, that if proper care be taken in the laying and in the application of the filler, cement grout will give the best results, as it will come more nearly to making the pavement a monolith. Some trouble has occurred in the past with this filler on account of the rumbling of the pavement under traffic. This trouble, however, has been nearly if not entirely obviated. There is the objection to a cement filler, however, that it is more difficult to open a pavement and replace it in case it becomes necessary on account of the subsurface work.

It is almost impossible to set any figure for the life of a brick pavement or the cost of repairs, as these depend almost entirely upon traffic. The figures given in the table have been made out principally from data received from large cities, and undoubtedly they would be modified if obtained from the State of Ohio, for instance. But as has previously been said, all figures of the table must be adapted to local conditions. The results determined upon are shown in the table.

Asphalt Pavements.—Under the head of asphalt will be considered sheet asphalt, asphalt blocks and bitulithic, although the latter is perhaps more often used with coal tar pitch than with asphalt.

Sheet Asphalt.—The first pavement of any note of this character was laid on Pennsylvania Avenue, Washington, D.C., in 1876. So great was its success that it soon came into general use all over the country. While called asphalt pavement, it is almost entirely composed of sand, as the standard pavements have but 10 to 12 per cent. of bitumen, which is the valuable property of the asphalt, the rest being made up of sand and a small portion of stone dust. The pavement is pleasing in appearance, smooth, not noisy, and on light traffic streets seems to be almost ideal. It is more slippery than the hard block pavements, and in the coast cities it is not generally laid on grades over 3 or 4 per cent. In the interior, however, where the atmosphere contains less moisture, it is often used on grades as high as 7 per cent. without trouble.

Data collected from the cities of Brooklyn, Boston, Buffalo, Chicago, New York, Philadelphia, St. Louis and Washington show that these cities in 1890 had a total of 246 miles of asphalt pavement, and in 1911 2,348 miles. This gives an idea of the popularity of the pavement, although it must be taken into consideration that this was during a period when there was great activity in laying new and smooth pavements. In Brooklyn, for instance, in 1895, there were 18 miles of asphalt pavement, while at the present time there are 540 miles. Brooklyn is a residential city, without many steep grades, and one to which this material is particularly adapted.

The cost of repairs to the asphalt pavements in the Borough of Brooklyn in 1913 was 3½ cents per square yard, and in the Borough of Manhattan for 1912 it was 14.1 cents per square yard, this being due to a great extent to the difference in traffic in the two cities. In the City of Paris in 1911 the cost was 19½ cents per square yard.

In Berlin asphalt repairs are made by contract. The price paid is for streets from 5 to 20 years old, 10 cents per square yard; from 20 to 30 years old, 12½ cents per square yard; from 30 to 40 years old, 15 cents per square yard.

In London the contract price on Cheapside per yard per year was 56 cents for 15 years beginning after the pavement had been down 2 years. The average cost of repairs in London is 30 cents per yard.

Asphalt Block.—This is another form of asphalt pavement and consists of blocks, made under heavy pressure at a central plant, composed of asphalt and broken stone aggregate rather than sand, as is used in the sheet pavement. The mixture of the material can be absolutely regulated and the pressure made uniform, so that the blocks produced should be uniform in density and quality. On account of the stone aggregate being coarser (say from ¼ inch downward) than the sand, the surface of the pavement affords a better foothold than the sheet asphalt, and also on account of the joints between the blocks. So that where a smooth pavement on grades is desired asphalt blocks are particularly desirable. They are used, of course, to a great extent on streets of light grades.

An objection to them is that as they have to be manufactured at one location the entire surface of the pavement must be transported from the plant to the street, while with sheet asphalt the plant can be located at a convenient point so that the haul is not so large. This makes a difference in the expense against the asphalt blocks. On the other hand, however, an asphalt block pavement can be repaired without the use of a mixing plant, as the blocks can be purchased and brought upon the street and used when desired.

Asphalt block pavements in the Borough of Manhattan in 1912 cost 9.8 cents per square yard for repairs, and in the Borough of Brooklyn for 1913 1.2 cents per square yard.

Bitulithic Pavements.—This pavement was first laid about ten years ago. A gentleman who had formerly been interested is asphalt pavements conceived the idea of improving the then existing methods of laying a macadam pavement by filling a portion of the voids with a bituminous product or bitumen mixed with some other material. By the gradual elaboration of his original idea there was evolved a pavement which is now known as "bitulithic." It is essentially a macadam pavement of selected and graded stone, so that the voids in the stone shall be as small as possible, the binder being a bitumen, either coal tar or asphalt, both having been used. The pavement, being formed of coarse materials, can be laid on quite steep grades with satisfactory results. It has been laid very extensively in this country and would undoubtedly have been used to a greater extent if it were not patented. It is considered as standard and ranks with asphalt pavements.

Sheet asphalt, asphalt block and bitulithic pavements are given the same values, as shown.

The table then is as follows:

	Per cent.	Granite.	Wood.	Asphalt.	Brick.
Cheapness	14	8	8	14	11
Durability	21	21	16	15	16
Easiness of cleaning...	15	10	14	14	15
Light resistance to traffic	15	13	14	12	15
Non-slipperiness	7	7	4	5	6
Ease of maintenance ..	10	10	8	6	6
Favorableness to travel	5	2	5	4	3
Sanitariness	13	9	13	12	10
Totals	100	80	82	82	82
Cheapness eliminated ..		72	74	68	71

Heavy traffic.				High-class residential.				Ordinary residential.			
Gran.	Wood.	Asph.	Brick.	Gran.	Wood.	Asph.	Brick.	Gran.	Wood.	Asph.	Brick.
21	16	15	16	10	14	14	15	Omitting light resistance to traffic.			
13	14	12	15	7	4	5	6				
7	4	5	6	2	5	4	3				
10	8	6	6	9	13	12	10				
51	42	38	43	28	36	35	34	67	68	70	87

Knowing, however, the kind of material and the properties thereof are not sufficient for the official whose duty it is to determine the particular one to be used. He should also know the requirements of the streets to be paved. In order to do this he should have records of the kind and character of the traffic upon each street, or upon typical streets. Of course it is not necessary to get a total census of traffic on all residential streets, but of those where by an inspection it can be told to what class they belong.

And in speaking of traffic it should be understood that as at present considered the words "heavy," "medium," and "light" traffic mean very little, except with reference to any one particular city. There should be a standard unit of traffic, so that when the traffic on a certain street is given it could be distinctly comparable with traffic in another city. To do this it is necessary that the effect upon the different materials be known. Little attempt has been made to determine this, but within the last two or three years the English Road Board has constructed a machine for making this determination, and a somewhat similar machine was exhibited at the American Highways Association meeting in Detroit last fall.

It can be easily understood that a vehicle weighing with its load 15 tons will have an entirely different effect upon a pavement than fifteen vehicles each weighing 1 ton. It makes a difference, too, whether the tires are steel or rubber, whether they are 1 inch or 3 inches in width, and whether the vehicle is moving at a rate of 6 or 30 miles an hour. Experiments can be made so that the wear of the different vehicles under different loads can be ascertained and referred to one unit, and until this is done the adjectives "heavy," "medium," and "light" must be considered very indefinite.

The borough engineer of Fulham, London, has established what he thinks is the wear that will take place on wood pavements under a certain traffic, and, having observed the traffic on any particular street, he figures out how long a wood pavement should last. This, however, is indefinite for the reasons before given.

And even after the value of the traffic unit has been established it will be difficult to apply it positively, as in every case the weight of the vehicles upon it must be estimated.

Then, after all that has been determined, there are certain local conditions which must also be taken into consideration. For instance, if the traffic requirements are such that a brick or stone pavement should be used for economic reasons, it is possible that hospitals, school houses or churches may be situated on certain portions of the streets, so that it would be necessary to lay wood on account of its noiseless property. Then, too, the official will learn that the wishes of the users of the street and those doing business on it must also be taken into consideration, and he often finds that the two will conflict, as the truckman cares nothing about the noise and the businessman cares little for tractive or non-slippery properties. So that, despite all information that can be obtained, in order to arrive at a satisfactory result the different conclusions must be treated together and intelligently. If, however, all these matters are taken into consideration, it is seldom that an improper determination will be made.

It might be in order to discuss to a certain extent the economics of the different kinds of pavement. When an original pavement is paid for by assessment upon the abutting property, with repairs and repaving done by the city at large, it often becomes necessary to establish legally just when a street should be repaved. This is more easily determined by inspection in a block pavement than in a sheet pavement, as it can easily be seen when the blocks are worn out, but with a sheet pavement patching can be carried on for a long time and to a great extent without there being any formal repaving. Take for instance the case of an asphalt pavement, and assume for the sake of the illustration that the original pavement is paid for by a bond issue continued during the life of the pavement, which in this case is assumed at 18 years. The

The items of cost in the maintenance of this pavement on a street are:

First cost;

Interest on the bonds;

Annual repairs;

A sinking fund to be collected each year to pay for the bonds when they mature.

Assume that an asphalt pavement will cost $2 per square yard, that the interest on the bonds is 4 per cent., and that it will cost on an average 4 cents per square yard per year for repairs. This can be shown in a formula, such as:

$$A + CI + \frac{R}{N} = \text{annual expense},$$

—when A equals sinking fund charges, C equals first cost, I equals rate of interest, R the estimated cost of total repairs during the life of the pavement, and N the life of the proposed pavement.

Substituting these values in equation we have:

$$.078 + .08 + \frac{72}{18} = .198 \text{ for the first period};$$

—that is, the cost to be raised by the city every year to maintain this pavement would be 19.8 cents per square yard. When, therefore, the annual repairs on a street approximate this amount the question of repaving should be carefully considered. If, however, the same pavement is continued upon the street, succeeding pavements would cost less, as the foundation must have a material value.

RUSTING OF IRON IN WATER.

Many years ago Crace Calvert concluded that the rusting of iron in water was occasioned by dissolved carbonic acid and oxygen, the former being the predisposing cause, since no action occurred in its absence. These conclusions have since been widely supported. Experiments conducted by W. A. Bradbury, according to Chemical News, show that rusting takes place very rapidly in tap-water, while in well-boiled tap-water no rusting should occur. During rusting atmospheric oxygen is absorbed. The solution of iron by carbonic acid should result in the production of hydrogen, thus $Fe + 2H_2CO_3 = FeH_2(CO_3)_2 + H_2$, but in experiments with tap-water no gas could be collected after over a week. Water saturated with CO_2 did evolve considerable quantities of gas. These experiments confirm the view that rusting is due to the combined action of oxygen and carbonic acid, and show that the oxygen is utilized in two ways: (a) in the oxidation of the nascent hydrogen liberated, and (b) in the oxidation of the iron bicarbonate to rust. Further tests showed that magnesium chloride solution does not act on iron in the absence of carbonic acid, although it has been stated that such solutions do react with iron, even in the cold, according to the equation—$Fe + MgCl_2 + 2H_2O = Mg(OH)_2 + FeCl_2 + H_2$.

NATURAL GAS PRODUCTION IN UNITED STATES.

The production of natural gas in the United States last year was the greatest in the history of the industry. The total gas production in 1913 is estimated by the United States Geological Survey at 581,898,239,000 cubic feet, valued at $87,846,677, an average price of 15.10 cents per 1,000 cubic feet, as compared with a production of 562,203,452,000 cubic feet, valued at $84,563,957, an average price of 15.04 cents in 1912. Of this total product, about 32 per cent. was utilized for domestic purposes, at an average price of 27.33 cents per 1,000 cubic feet, and 68 per cent. utilized for industrial purposes, at an average price of 9.4 cents. The industrial consumption includes gas used for both manufacturing and producing power.

Coast to Coast

Saskatoon, Sask.—Twelve carloads of cement are weekly being mixed and placed on the new bridge over the South Saskatchewan, at 25th Street, Saskatoon. A pneumatic concrete mixer is being used, and it is expected that the arch rings of the bridge will be completed before the frost sets in. Each arch ring contains about 500 yards of concrete, and the mixer and placer fills one of these in 17½ hours. When completed, it is said, the bridge will be one of the largest and most beautiful arch bridges in Canada.

Edmonton, Alta.—The offer recently made by the Wabamun Power and Coal Company to the city of Edmonton is to supply the city with electrical energy delivered to any point within the limits, the first 25,000,000 k.w.h. at 1 cent, the next 10,000,000 at .95, the next 15,000,000 at .90, then 20,000,000 at .70, and the following 20,000,000 at .65 per k.w.h. In addition, the foregoing prices would be considered as taking care of the load of the city at time of delivery, which would not be later than the fall of 1915. The property of the Wabamun Power and Coal Company is located 28 miles west of the city on the main line of the G.T.P., and includes a mile on the shore of Lake Wabamun, which makes readily available an unlimited supply of water for boiler purposes. Though the company will agree not to sell power to any outside concern at a lower rate than that offered to the city, yet the company is negotiating for the establishment of a plant of sufficient capacity to supply power also to the towns of Wabamun, St. Albert, Calder and other communities along its route to Edmonton. The term of the contract offered for consideration is for 25 years; though the company would agree to supply Edmonton's electrical energy for a period of 150 years. Also, the contract contains the proviso that the company will sell to the city at any period agreed upon the entire plant, transmission line, mine and all assets of the company at a price equal to the cost and 10 per cent. profit.

Cedars Rapids, Que.—A report recently issued by the Cedars Rapids Manufacturing and Power Company covering the progress made upon the company's plant during the four months ending August 31, showed 93 per cent. of the rock and 97 per cent. of the earth excavation completed; while four months ago, 58 per cent. and 73 per cent. respectively were the amounts reported. Of the rock excavated, 94 per cent. had been transported and placed; and of the earth excavated 97 per cent. had been replaced. The concrete in the power house structure was completed, all that remained to be done being the placing of the stone protection, 50 per cent. of which was completed. Half the work on the transformer house was done during the past period, the other half still remaining to be completed. The power house building was substantially completed, and work had been started on the wing dam at the north end. The north end of the building had also been closed in. According to the report, the removal of the balance of the material in the tailrace would be substantially completed by October 1: and the tailrace coffer-dam would then be removed. Three generators had been completely erected in the power house, and were ready for operation, and work was well advanced on all the remaining units. The transformer house, 60 per cent. of which was already completed, was constructed by the unit method, with the exception of the columns, which were cast in place. Practically all of the slabs which go to make up this building had been cast; and the work of assembling them was progressing rapidly.

PERSONAL.

H. A. McLEAN is leaving Sarnia, Ont., where he has for some years held the position of city engineer.

R. J. McLELLAN, city engineer of Kingston, attended the convention of the Electric Railway Engineering Association in Atlantic City.

J. HENRI DUBUC, previously engineer of highway bridges in the city engineer's office, Montreal, has been appointed chief clerk in addition to his former duties.

R. A. CAMPBELL has resigned his position as superintendent of the Tagona Water and Light Company, Sault Ste. Marie, and has been succeeded by R. D. S. BECKSTEDT, B.A.Sc.

J. E. ALDRED, of New York, president of the Cedars Rapids Manufacturing and Power Company, paid a visit last week to the company's power development now under construction near Montreal.

E. J. REED, formerly sales manager of Miles, Sykes and Son, Limited, and for several years chief publicity writer for the British Westinghouse Company, has been appointed advertising manager of Ed. Bennis and Company, Limited, of Bolton, England, manufacturers of mechanical stoking apparatus.

M. C. HENDRIE, hydraulic engineer, Water Power Branch, Department of the Interior, Ottawa, addressed the recent Irrigation Congress in Calgary on the power and storage investigations of the Department on the Bow River, west of Calgary. These investigations, as has been already stated in these columns, show that there is available for development over 50,000 dependable 24-hour h.p.

OBITUARY.

An accident occurred on August 12th in the vicinity of La Tuque, on the construction of the National Transcontinental Railway in which Mr. A. H. Johns, resident engineer, lost his life.

CANADIAN SOCIETY OF CIVIL ENGINEERS, OTTAWA BRANCH.

The annual meeting of the Ottawa Branch of the Canadian Society of Civil Engineers was held on Oct. 7th in the rooms of the Commission of Conservation, through the courtesy of Mr. James White, assistant to the chairman of the Commission.

The retiring chairman, Mr. Geo. A. Mountain, gave a very suitable address, reviewing the work of the past year and commenting favorably upon the large attendance at meetings. On several occasions over 300 were present. The Committees on Library, Rooms, Entertainment and Papers presented reports. The Secretary-Treasurer's report indicated that the affairs of the Branch are in very satisfactory condition. It was announced, however, that new headquarters will shortly be required.

The membership of the Branch has increased since the last annual meeting. Three deaths, however, have occurred in the persons of Ambrose Duffy, R. W. Farley and T. H. Schwitzer. A number of members have gone to the front.

The election of officers resulted in the following executive:—

Chairman—A. St. Laurent, Assistant Deputy Minister of Public Works, Canada.

Secretary-Treasurer—A. B. Lambe (re-elected).

Managing Committee—W. J. Dick, R. de B. Corriveau, W. F. Cochrane, Alex. Gray and W. S. Lawson.

MANUFACTURE OF ASBESTOS PRODUCTS IN CANADA.

A list of engineering supplies used, but not manufactured, in the Dominion was published in *The Canadian Engineer* for Oct. 8th, page 520. It was compiled from a more exhaustive list issued by the Department of Trade and Commerce, Ottawa, serving as suggestions for manufacturers.

The list included asbestos pipe covering as an article not manufactured in this country. On the contrary, however, the Asbestos Manufacturing Company, Limited, Montreal, with a large plant in operation at Lachine, Que., turns out all kinds of asbestos products, including pipe covering.

It is 85 per cent. magnesia pipe covering that is not manufactured here.

MR. JANIN'S ENGINEERING CORPS.

A formation of an engineering corps for active service with the English and French forces in the field has been effected by Mr. Geo. Janin, chief engineer of Montreal. Membership in the corps has been over-applied for. Subscriptions aggregating about $6,000 have been raised for the purposes of organization. The men are training at the Engineers' Armory in Point St. Charles.

MANITOBA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

On Oct. 8th the Manitoba Branch held its first meeting of the season, Professor E. Brydone-Jack presiding. The speaker was W. G. Chace, B.A.Sc., chief engineer of the Greater Winnipeg Water District, who explained many of the features of the Shoal Lake water project now under way. He traced the efforts made by the city to obtain an adequate water supply, and leading up to the adoption of the present undertaking.

CALGARY BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

On Oct. 6th the Calgary Branch entertained the engineers in attendance at the International Irrigation Congress. The banquet was presided over by Mr. H. B. Muckleston, assistant engineer, Department of Natural Resources, Canadian Pacific Railway, and chairman of the Branch. Mr. F. H. Newell, Director of the United States Reclamation Service, was a speaker. The keynote of his remarks was the necessity of an engineer getting into close touch with the men who would prove out his work. Mr. S. M. Savage, supervising engineer of the St. Mary's Milk River project; Mr. D. W. Ross, consulting engineer, California, and Mr. Wm. Young, comptroller of Water Rights, British Columbia, were prominent among the speakers of the evening.

The Manchester Municipal School of Technology, England, has recently issued a notice to all graduates in the hope of securing a complete return with a view to ascertaining how many of its students, past and present, have enrolled for service, whether in the Navy, in the Regular Army, in the Territorial Force or on Medical or other service. We trust that those of our readers who are members of the college, and who have been out of touch with the registrar, will comply with the request which this notice implies.

Volume 27. Toronto, October 29, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

DON SECTION, BLOOR STREET VIADUCT, TORONTO

SOME NOTES ON THE PRELIMINARY WORK ATTENDING THE WHOLE PROJECT—FOUNDATION TESTS—FEATURES OF DESIGN OF DON RIVER SECTION.

THE rapid development during recent years of the northeastern section of the city of Toronto has produced an acute need for better transportation facilities across the Don river. While the business and residential sections of the city lie almost entirely west of this river and the ravines adjacent to it, annexation and development has resulted in a large and increasing population which is served by two thoroughfares; *viz.*, the Queen St. bridge, accommodating practically all downtown traffic over the Don, and the Gerrard St. bridge. These thoroughfares are both relatively near the waterfront, and necessitate considerable deviation of traffic that rightly belongs to the northern portion of the city, together with an excessive congestion at busy periods of the day, along the present avenues of communication.

With the development of the Danforth Avenue section of the city and the establishment of a civic car line to convey traffic between the extreme eastern section of the city and the bank of the river (where communication with the business section of the city is effected by transfer to a south-bound car service) it became more and more obvious that a viaduct to span the Don river and Rosedale ravine, thereby affording direct transport to and from Bloor Street and the central portion of the city, was required, to dispense with the handicap which had so long prevailed both to freight and passenger traffic.

During the summer of 1912 the Department of Works of the city, under the direction of Commissioner of Works R. C. Harris, made a thorough survey of the best available route, taking all necessary levels, cross-sections, etc., to enable the Department to prepare plans and specifications for the proposed viaduct. In addition to information regarding the physical condition of the site, it was necessary to collect and arrange a great deal of information relative to the growing demand of city traffic, both surface and underground. In January, 1913, a by-law was passed by the ratepayers authorizing the sum of $2,500,000 to be expended on the enterprise. Since that time the investigations have been carried on to the most minute detail and have just recently been completed. At the present time tenders for the Don section of the viaduct are under consideration, and it is probable that tenders will be solicited for the Rosedale section in a short time.

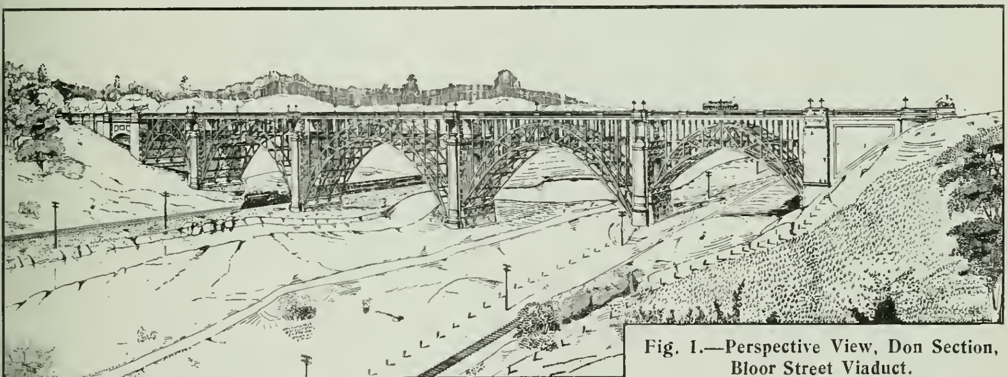

Fig. 1.—Perspective View, Don Section, Bloor Street Viaduct.

The surveys for the whole of the viaduct consist in general of its alignment, together with that of the adjacent streets and properties likely to be affected; the taking of levels for a distance of 100 ft. from the centre line on either side, at 10-ft. intervals, the results therefrom giving cross-sections for every 10 ft. between Sherbourne Street on the west and Broadview Avenue on the east side of the site. These cross-sections were necessarily very extensive at certain places, particularly between Sherbourne Street and Edgedale Road, in the Rosedale Valley between Parliament Street and Castle Frank Road, and also on the east side of the Don Valley. To facilitate measurements during the process of construction, permanent monuments were set and their location and elevation carefully determined.

In addition to the topographical work, extensive subsurface exploration was necessary. This included about 3,400 ft. of wash-boring and core-boring. Samples were carefully taken, labeled and preserved for reference. The rock found at varying depths consists of a shale.

Owing to the high unit stresses which the main piers of the proposed structure will impose on the shale, tests were made to determine as accurately as possible its safe carrying capacity. As the cores obtained by the use of the diamond drill were too small for compression tests, samples were selected from the quarry of the Don Valley Brick Works, in comparatively close proximity to the site. Care was taken to select the softest pieces obtainable and of the same character as the softest shale encountered in the boring operations. On account of the nature of this shale it was impossible to obtain good specimens.

Six test blocks, however, were obtained, of approximately cubical form, 2 inches to the side. These were tested to destruction, failure occurring under loads of 1,381, 831, 535, 1,500, 862 and 362 pounds per square inch respectively.

To acquire a fairer estimate of the carrying capacity of this material in place, the waterworks sections and the railway and bridge section of the city's Department of Works co-operated in making two loading tests on similar shale exposed in an excavation at the main pumping station. These tests were of the following nature: A steel platform was constructed with a bearing 8⅛ inches square. Weighed pig iron was placed upon it until the desired loading was obtained. On account of the settlements being small, special measuring devices were used and the total settlement checked by means of the level and target rod. In the first test a settlement of .45 inches was recorded under a unit pressure of 986 lbs. per square inch. Careful examination of the rock after the removal of the platform was made and the shale was found to be crushed only to such a degree as to have lost its characteristic structure for a depth of about 3 inches, while the shale immediately surrounding the loaded area showed no sign of injury.

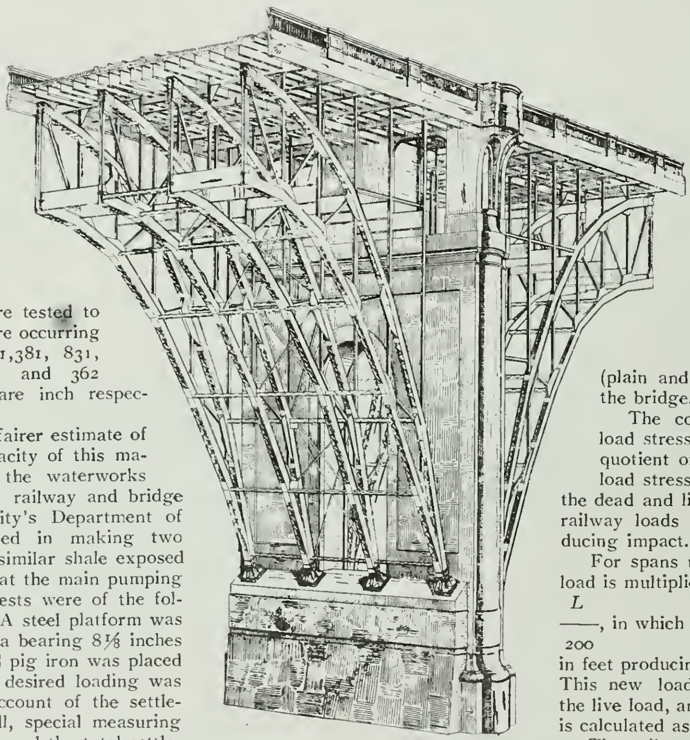

Fig. 2.—Perspective View of Pier "D."

In the second loading test a unit pressure of 402 lbs. per square inch was imposed, resulting in a settlement of .08 inches. Examination after the test showed that its effect on the texture of the shale could scarcely be observed.

The design of the Don section of the viaduct shown in Fig. 1 is based upon a steel structure with approaches and piers of reinforced concrete. It is a three-hinged, four-ribbed arch construction of five spans with footings carried down to rock foundation. The floor system is of concrete slabs supported on steel. The whole structure is 1,618 feet in length with a height of 130 feet above water level. The river span is 281½ feet, with a span of 240 feet, on either side, and on the outer side of these again, spans of 158 feet. The western approach will include a span of 80 feet. The specifications call for 26,175 cu. yds. and 3,050 cu. yds. of excavation for the east and west approaches respectively, and 20,000 cu. yds. for the piers. About 5,500 tons of structural steel and 43,000 cu. yds. of concrete will be required. As will be noted in the cross-section (Fig. 3) the design provides for a 20-ft. roadway on either side of car tracks, placed 11 ft. 11 in. c. to c. On either side, also, is a cantilevered sidewalk 10 ft. 9 in. in width, making a total width of 86 ft. Provision is made for the installation of a lower deck to connect with a future system of underground railways. A 42-in. water main will also be carried on either side under the main floor structure.

The following are among the assumptions governing the design of the concrete (plain and reinforced) portions of the bridge.

The combined dead and live load stresses are increased by the quotient of the square of the live load stress, divided by the sum of the dead and live load stresses. Only railway loads are considered as producing impact.

For spans under 80 feet, the live load is multiplied by the factor $1.40 - \frac{L}{200}$, in which L is the loaded distance in feet producing the maximum stress. This new loading is then considered the live load, and the impact allowance is calculated as above.

The rails and ballast are assumed to distribute each wheel load uniformly over a length of 5 feet. The load on each track is assumed to be distributed over a width equal to the length of ties plus one foot.

In calculating bending stresses produced in the slab by the 20-ton truck, each wheel load is assumed to be distributed over a square, each side of which is equal to 9 inches, plus the effective depth of the slab. In calculating punching shear produced in the slab by the 20-ton truck, the area of contact is considered as a square 9 inches to the side.

The length of span for reinforced concrete subjected to bending shall, in general, be considered to be the distance centre to centre of supports.

All slabs are considered, unless otherwise shown on the drawings, to be partially continuous and shall have reinforcing in the upper portions at the supports. In all

such cases the maximum positive bending moment in each individual span is taken as eight-tenths of that which would be produced in the same span resting freely on two supports, and the negative bending moment over intermediate supports is taken as ten-twelfths of the maximum positive bending moment in an adjacent span.

For beams and slabs the straight-line formula has been used, based on the following assumptions:

(*a*) All tensile stresses are considered to be resisted entirely by the steel reinforcing.

(*b*) There are no initial stresses in the beams.

(*c*) All shearing strain is cared for and there is no slipping between concrete and steel.

(*d*) The modulus of elasticity of concrete in compression is constant up to the limit of the allowable working stress.

(*e*) A section, plane before bending, remains plane after bending; that is, the stress on any fibre is directly proportional to its distance from the neutral axis.

Diagonal tension existing simultaneously with the maximum bending moment is considered as provided for by the concrete without web reinforcement, when the quotient of the vertical shear and the area between the centre of steel and centre of compression in the concrete does not exceed 50 lbs. per square inch.

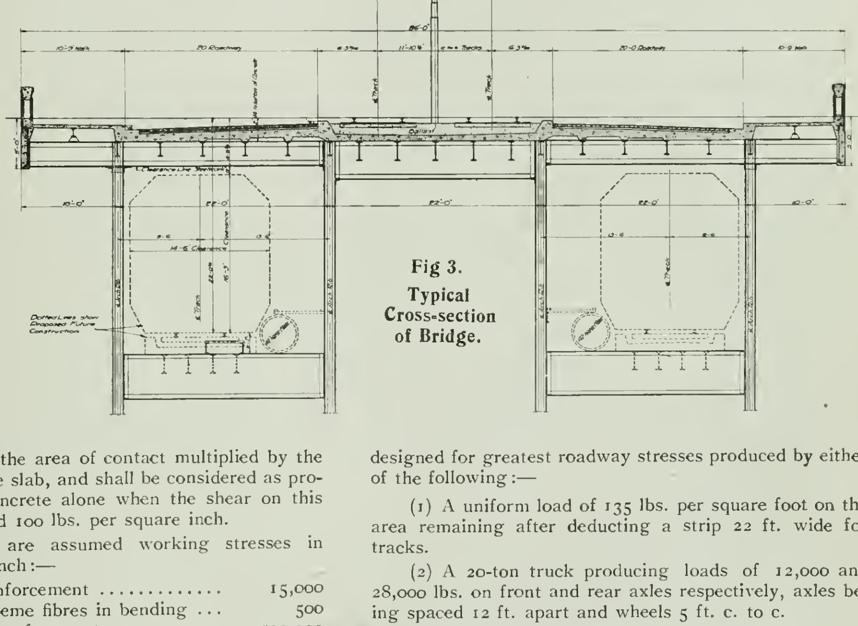

Fig 3. Typical Cross-section of Bridge.

Punching is assumed to be resisted by an area of concrete equal to the perimeter of the area of contact multiplied by the effective depth of the slab, and shall be considered as provided for by the concrete alone when the shear on this area does not exceed 100 lbs. per square inch.

The following are assumed working stresses in pounds per square inch:—

Tension in steel reinforcement	15,000
Compression in extreme fibres in bending	500
Modulus of elasticity of concrete	1,500,000
Modulus of elasticity of steel	30,000,000
Compression on 1:2:4 concrete under bearing plates and pad stones	400
Compression on 1:2½:5 concrete in body of pier	350
Compression on 1:3:5 concrete in caissons	300
Bond between deformed bars and concrete	100

The following assumptions are among those governing the structural steel designing:—

The steelwork is arranged to provide for the future traffic on the lower level, the clearance being 17 ft. 3 in. in height and 14 ft. 6 in. in width for each of two tracks. The top corners are bevelled 3 ft. 9 in. to a side, and the base has a width of 11 ft. 6 in. at rail level. Clearance is also provided for installation of two 42-in. water mains.

For purposes of dead load stress computation the weights of the different substances are assumed as follows:—

Concrete (plain or reinforced)	150 lbs. per cu ft.
Steel, as ordinarily listed per lin. ft.	
Broken stone ballast	100 lbs. per cu. ft.
Timber ties	54 lbs. per cu. ft.
4-inch wood block paving and ½-inch sand cushion	25 lbs. per sq. ft.
Rammed sand or gravel	125 lbs. per cu. ft.
Loose sand and earth	100 lbs. per cu. ft.

The floor system and posts are designed to carry on each upper deck track two 50-ton electric cars, producing live loads of 25,000 lbs. per axle (4 per car), the spacing in feet being 5 ft. 6 in. : 20 ft. : 5 ft. 6 in. : : 13 ft. : : 5 ft. 6 in. : 20 ft. : 5 ft. 6 in.

The arches and foundations are designed for a uniform load of 1,600 pounds per lineal foot of electric railway track.

The floor system and posts are designed for greatest roadway stresses produced by either of the following:—

(1) A uniform load of 135 lbs. per square foot on the area remaining after deducting a strip 22 ft. wide for tracks.

(2) A 20-ton truck producing loads of 12,000 and 28,000 lbs. on front and rear axles respectively, axles being spaced 12 ft. apart and wheels 5 ft. c. to c.

The arches and foundations are designed for a uniform load of 80 pounds per square foot for spans of 200 feet or over, and $80 + \frac{200-S}{5}$ pounds per square foot for spans under 200 feet. (S = span in feet.)

The slab, stringers, and posts for the sidewalk are designed for a uniform load of 100 pounds per square foot and the arches and foundations for a uniform load of 80 pounds per square foot.

The bridge is designed for a wind pressure of 50 pounds per square foot on the unloaded structure. For the upper deck the wind pressure is assumed to act on a vertical surface, ten feet in height from bottom of stringers upward. For the lower deck it is assumed to act on a vertical surface four feet in height taken twice.

For the truss members and posts it is assumed to act on twice the exposed area of one rib.

Each part of the structure shall be so proportioned that the maximum condition of stress in pounds per square inch shall not exceed the following:

Axial tension on net section of rolled plates and shapes 16,000

Axial compression on gross section of rolled plates and shapes:—

For flat or fixed ends, $16{,}000 \div \left(1 + \dfrac{L^2}{18{,}000\, r^2}\right)$

For one flat and one pin end, $16{,}000 \div \left(1 + \dfrac{L^2}{12{,}000\, r^2}\right)$

For pins at both ends, $16{,}000 \div \left(1 + \dfrac{L^2}{9{,}000\, r^2}\right)$

where L is the length of the member in inches and r is the least radius of gyration in inches.

Bending, on extreme fibres of rolled shapes, built sections, and girders, net section 16,000

Shearing, shop-driven rivets in reamed or drilled holes 10,000

Power-driven field rivets in reamed or drilled holes 9,000

All other field rivets 8,000

Lathe-turned bolts in reamed or drilled holes ... 8,000

Webs of girders, gross area 10,000

Bearing on diameter of rivets, twice the shearing value given above.

Bearing on pins 22,000

No compression member is to have a length exceeding 45 times its least width, nor an unsupported length in any direction exceeding 100 times its least radius of gyration about an axis perpendicular to that direction, excepting wind bracing and lateral struts, which may have an unsupported length of 120 times the least radius of gyration.

The preliminary work has been done, and the bridge designed, by the staff of the Department of Works, City of Toronto, assisted as regards architectural features of piers, approaches, and handrail, by Mr. Edmund Burke, Toronto, in the capacity of consulting architect. Considerable controversy has been created in connection with the proposed development as to the material, steel or concrete, that should be used, the nature of the soil structure having a very important bearing upon the question. The City Council has permitted the submission of tenders for both steel and concrete, and, as already announced in this journal, four of the former and five of the latter are under consideration.

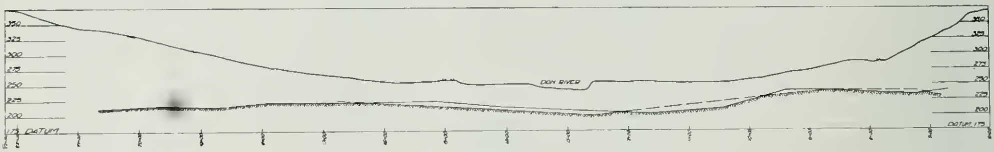

Fig. 4.—Profile of Don Section.

THE PITOT TUBE THEORY.

In *The Canadian Engineer* for May 28th, 1914, Page 784, a paper appeared entitled "Remarks on the Theory of the Pitot Tube," by N. W. Akimoff. The following discussion of the paper has recently appeared in the Journal of the American Water Works Association. The writer is Mr. J. W. Le Doux:

There has been recently a large amount of discussion of the apparatus known as "Pitot tube," the points of greatest interest being the shape and arrangement of the openings; the methods of calibration; the influence of disturbing factors; the formula of flow, particularly as to the term "g" representing the acceleration of gravity, and the constancy of the coefficient throughout the range of the velocity.

In regard to the first it would seem to the writer that as any particular form requires calibration, that which is the simplest and easiest to handle, offers no material obstruction to the flowing water and produces the highest deflection of head for a given velocity should be the most satisfactory.

It has been held that the results are different if a tube is moved in still water from what they are if the tube is stationary and the water moves. It is hard to see how this can be so, providing the conditions are alike in each case; for instance: if a long column of water of the same uniform cross-section be used for each determination. If a Pitot tube be made to advance at uniform speed through the centre of a canal of uniform cross-section, the coefficient thus determined should be the same as if the Pitot tube were stationary in the same relative position and the column of water advanced at the same velocity. If, however, the coefficient were determined under the first of these conditions and afterwards placed in a circular pipe under pressure, it is conceivable that the coefficient would be different, although if moving and still water determinations could be made for the pipe itself, the results might be the same.

The influence of disturbing factors, such as the proximity of fittings or variation in the shape of the conduit or pipe, can never be allowed for in advance, and the proper thing to do is to avoid them as far as possible.

The formula of a Pitot tube, as well as that of the flow through all orifices or contractions in a pipe, is almost universally recognized to be that of a parabola, which is the simplest formula of a conic section, there being but two terms and two variables, one of these being in the first power and the other in the second. The first variable is the head or pressure, and the second the velocity, or quantity flowing. The parabola formula can be placed in the form of $v^2 = c\,h$, in which h is the head, v the velocity, c a constant.

If this formula is true and c is a true constant, it is only necessary to obtain the value of h and v experimentally which will determine c by calculation, and when this is once found it is good for all other values.

As the formula is one of bodies moving under the action of gravity, it is evident that the constant is influenced by the term "g"; that, however, need not concern us as long as we have to determine the constant anyway by experimental methods, and it is very important that this determination be made under such conditions as will obtain in subsequent practical use.

RAILWAY CONSTRUCTION IN SASKATCHEWAN.

In the annual report of the Saskatchewan Department of Railways the whole railway situation in the province is thoroughly canvassed, and the report contains much information, interesting as well as instructive.

The growth of operating railway mileage annually in Saskatchewan compared with the other provinces of the Dominion is shown in the following table in the report:—

Province.	1909. Increase.	1910. Increase.	1911. Increase.	1912. Increase.	1913. Increase.
Saskatchewan	550	301	189	633	897
Ontario	296	1	92	224	454
Quebec	89	132	87	1	103
Manitoba	94	16	245	54	473
Alberta	...	167	6	403	315
British Columbia	63	36	10	13	96

The following further statement of mileage of steel laid in Saskatchewan is furnished to indicate the history of railway construction in the province:—

	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
C.P.R.	1,090.1	1,181.4	1,235.85	1,528.84	1,650.39	1,819.14	2,080.18	2,271.38	2,479.34
C.N.R.	461.87	604.28	854.51	1,004.78	1,143.91	1,383.60	1,683.27	1,750.19	2,060.16
G.T.P.R.	....	....	154.08	260.67	465.15	531.75	635.75	873.09	1,087.36
Total	1,551.97	1,785.68	2,244.44	2,794.29	3,259.45	3,734.49	4,399.20	4,894.66	5,626.86

The following reference is made in the report to the effect of railway development in the province in the past and to the desire of the Government to see progress in the construction of branch lines maintained in the future:—

"The question of railway development in the province, despite the progress already made, remains one of paramount importance. The rapid development of the country impresses a realization of the need of railways. There are many rich and fruitful districts being retarded and vast regions remaining unopened and unproductive awaiting railway facilities. This lack of adequate means of transportation is the problem which has to be faced and which presses for solution. The population agriculturally employed is concerned in securing two things more than anything else, viz.: markets and transportation facilities to bring together the producers and consumers. That this is a matter of vital concern is plainly seen, for without markets and railways the industry of the farmer and the yield of the soil does not render him the best returns, the prices being generally determined by the facility and cost with which the produce can be placed on the market. For want of communication a great portion of the products of interior points possess little commercial value, but to which transportation facilities would give high commercial value. Increased rail transportation is necessary also to unite the different settlements which are now scattered and should be consolidated by providing means for social as well as commercial intercourse. The effect of railway development in the past touching the prosperity and well-being of the people has been perfectly obvious and appreciable, although not capable of being expressed in language or figures, and from this viewpoint it is earnestly to be desired that it will be possible for the era of railway expansion to continue, especially in view of the swelling immigration and development of the province."

A SIMPLE TYPE OF SECTION FOR MOVING A SHOVEL OVERLAND.

A. L. Van Dyke, of Woodstock, N.B., has given a description of a method, which he has used with much success, for moving a 70-ton shovel across country. Mr. Van Dyke states in the "Excavating Engineer" that when a shovel is to be moved for any distance it is most important to build sections instead of using rails, ties, and bridles.

Three 33-ft. sections are sufficient. Sixty-pound rails have been found suitable. These have not been found too light for the service. The rails are spiked to ties, of 3 by 6-in. hard pine, spaced about 8 in. apart. Beneath the rails, 3 by 12 or 16-in. hard pine planks are spiked to the bottom of the ties. To serve as runners, 1 by 3 or 4-in. strips are nailed beneath the planks.

In order to make the sections stiff, blocks should be put under the rails between the ties and spiked fast on top of the planks. The rails should be allowed to stick out from 4 to 6 in. over each end of the section, in order to provide clearance for easy connections. In making connections with the sections, use straps similar to those used with the ordinary 6-ft. sections, but instead of using a bolt and nut, use a spike with a key slot ¾ by ⅛ in. and a wedge-shaped key. This will prove simpler and more effective than bolts and nuts, as the threads are constantly being knocked off. To both ends of the fourth or fifth ties on each end of the section, fasten a ½ by 3-in. strap bent in a V shape.

Use two teams, one to pull the sections back from the rear of the shovel 6 or 8 ft., and the other to haul them around and in front of the shovel. Eight men with bars are sufficient to throw the section over in line, so connections can be made. Two others should be used to pull out and put in the bolts. In this manner, a mile to a mile and a half may be made in 10 hours without unduly driving the men. With 80-lb. rails, bridles, and ties, the work is very strenuous, and as a rule the men are exhausted by noon, consequently cutting down the progress in the afternoon. A turn can be made easily by using a 6-ft. section between the two long sections. Another advantage of the long section is that a shovel is not as liable to get off the track as is the case with ties and bridles. And even if this does happen it may be pulled on again easily by fastening a chain around one or two of the ties and the other end to the propelling chain. Jacks have rarely to be used.

COMPARATOR BUILDING OF THE DOMINION LAND SURVEY.

FOR some years the need has been keenly felt of proper facilities to test subsidiary standard tapes for the Dominion Land Surveyors. By the Dominion Land Surveys Act, the Surveyor-General is required to provide the surveyors with subsidiary standards tested and certified by him as correct. In order that these tapes might be properly tested and re-tested from time to time it was necessary to erect a building equipped with the most up-to-date apparatus for this purpose.

Building.—The building was of necessity of special design as it was of extreme importance that the temperature inside the building should vary as little as possible with any variation of outside temperature. It consists of two rooms, one a small room used as office and vestibule, and the other used for the testing. The inside dimensions of the main room are 150 feet long by 10 feet 6 inches wide with 12-foot ceiling. The walls are approximately 4 feet thick and consist of five thicknesses of brick, a 1-inch air space, sheeting, tar paper, 18 inches of shavings, 1 inch sheeting, 4 inch air space, tar paper and finally double sheeting. Between the ceiling and roof is a layer of shavings 4 ft. thick and beneath the floor a layer 2 ft. in thickness, under this cinders to a depth of 5 ft. to the solid rock. The only openings besides the door are two air intakes, one at each end of the room, and four ventilators in the ceiling. The air intakes (which are at the base of the wall) are arranged so that the quantity of air admitted can be regulated and during the tests can be completely shut off. Supported from the ceiling at each end of the room is an electric blower fan (shown in Figs. 2 and 3), used to circulate the air and so insure a uniform temperature throughout. The ceiling ventilators can be closed completely or opened any desired amount for ventilation. The exit into the outer room is of special construction, consisting of two doors with a 4-ft. air space between. The outer door is of the ordinary type, whilst the inner one is an insulating air-tight door of the refrigerator design.

In order to protect the apparatus from frost and moisture and also to raise the temperature to near standard temperature (62° F.) during the colder periods of the year an electric heating system was installed. Of necessity any system adopted must heat the testing room as uniformly as possible. A large number of small special heaters were used, placed around the walls near the floor. A double heater was also placed in each air intake in order to head the fresh air admitted. The heaters are of the three-heat type, giving low, medium and high heat. They may be controlled closely from a Vermont marble switchboard, the arrangement being designed so that different circuits may be regulated as to heat generated. The heaters with the conduit wiring may be noticed just above the floor in Figs. 2 and 3.

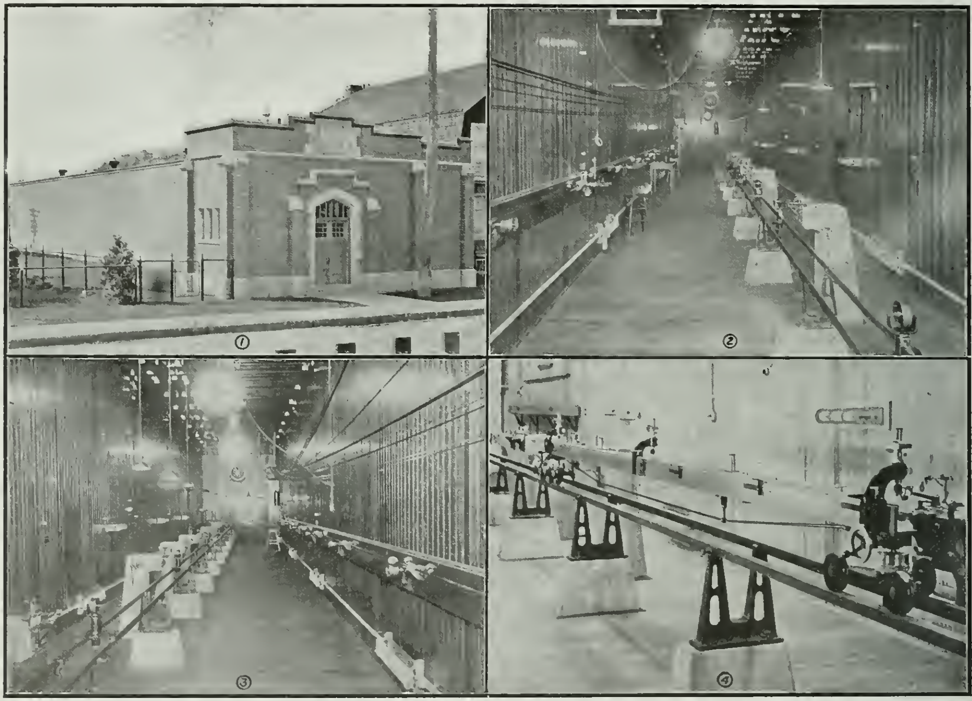

Fig. 1.—Exterior, Comparator Building; Figs. 2 (and 3).—Interior of Tape-testing Room, Looking North (and South); Fig. 4.—Meter Invar Bar in Position for Reading.

Apparatus.—Generally speaking, the existing bases for standardization of wires and tapes are of two types:

1st, The permanent bench marks of microscopic construction (*e.g.*, Russian bases at St. Petersburg); 2nd, the permanent bench marks consisting of lines traced on the edge of a series of polished surfaces (*e.g.*, bases of International Bureau and of the National Physical Laboratory). After careful consideration of the two systems it was decided to adopt the second one.

The apparatus installed was made by the Societe Genevoise pour la Construction d'instruments de physique Geneva. The general arrangement may be seen from Figs 2 and 3, the views being taken from the centre of the room looking towards the ends. The bench marks are permanently fixed to cement pillars. These pillars are isolated from the floor and extend down to solid rock. The bench marks are placed at 0^m, 4^m, 8^m, 10^m, 12^m, 50 ft., 16^m, 20^m, 66 ft., 24^m, 28^m, 30^m, 100 ft., and 32^m.

The distance between bench marks is determined by means of a standard invar bar 4 metres in length, standardized at the International Bureau of Weights and Measures at Paris. The bar is supported on a carriage which rolls over rails laid throughout the length of the base. This carriage, shown in Fig. 4, consists of two three-wheeled trucks supporting attachments for regulating vertical and horizontal movements. By this means the graduations on the bar and the bench marks may be brought very close together and the lines on the bar and bench marks sighted simultaneously by means of microscopes mounted on the carriage. Small two-candle power electric lamps are mounted on the piers to illuminate the graduations. The bar is protected by cases which rest on the support of the bar, the cases are notched at proper intervals to allow bringing the bar close to the bench mark and to uncover that portion of the bar in use.

The temperature of the bar is taken by means of two thermometers inside the case and read through openings in the latter. Suspended at equal intervals along the walls of the room and lying horizontally in cage guards are twelve delicate thermometers graduated to 0.1° C., it being possible to estimate to 0.01° C. By means of these thermometers an accurate determination of the room temperature may be obtained.

The rails which provide the runway for the carriage are supported every two metres by cast iron supports, these in turn being supported by cement piers isolated from the floor and carried down to solid rock. The iron supports are of U form to allow the tapes and wires to sag freely and to be freely manipulated. The supports used for suspending the tapes may be placed at any point along the runway and may be firmly clamped to the rails by means of two thumb-screws. The cord or wire which is fastened to the tape passes over a grooved pulley on the support and is attached to a weight to give the desired tension. The pulley is mounted on ball bearings and may be adjusted vertically or horizontally in order to bring the tape to the correct position. Intermediate supports which can be placed at any desired interval consist of pulleys mounted on ball bearings and are also adjustable.

As far as is known, only one set of apparatus exactly similar to that of the Dominion Government exists, this being one belonging to the Servian Government.

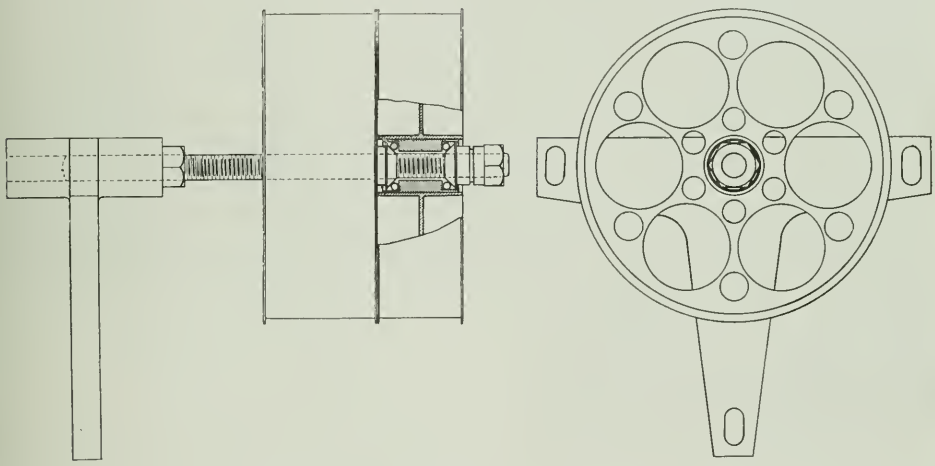

Fig. 5.—Intermediate Pulley Support for Tape-testing Apparatus.

The foregoing apparatus is used only to test the laboratory standards or when this method is specially requested by an engineer desiring to have tapes standardized. As previously mentioned, it is of extreme importance that the temperature of the room be as close to standard temperature as possible and also that the exact temperature be determined, as shown in the following example. If, during the comparison of a 100-ft. tape with the bench marks (the spacing of which does not appreciably alter with small variation of temperature), an error of 1/5° F. was made in determining the true temperature of the tape it would cause an error of .000124 ft. in the results due to dilation of the tape. The coefficient of dilation used is C = .0000062, which is an average value, but as this value has been found to vary with different tapes it is important that the temperatures during the test be kept as near as possible to the standard temperature (62° F.) at which the certificate is issued. If the tape is tested at 72° F., a variation of 10° F. from standard temperature, an error of .0000005 in the coefficient of dilation would cause an error of .0005 ft. in reducing the results to standard temperature.

In order that small changes of temperature might be neglected and that subsidiary standards be tested quickly and accurately, Dr. Deville, the Surveyor-General of Dominion Lands, decided to design a secondary apparatus, shown attached to wall on left and right of Figs. 2 and 3 respectively. This apparatus is so constructed that the tape to be tested is suspended on a series of delicate pulleys, side by side with one of the laboratory standards. The pulleys (Fig. 5) are in pairs mounted on the same shaft and the set supporting one tape may turn independently of the set under the other. Microscopes are provided to make the comparison and as the length of the laboratory standard is known to a high degree of accuracy, very accurate determinations may be made.

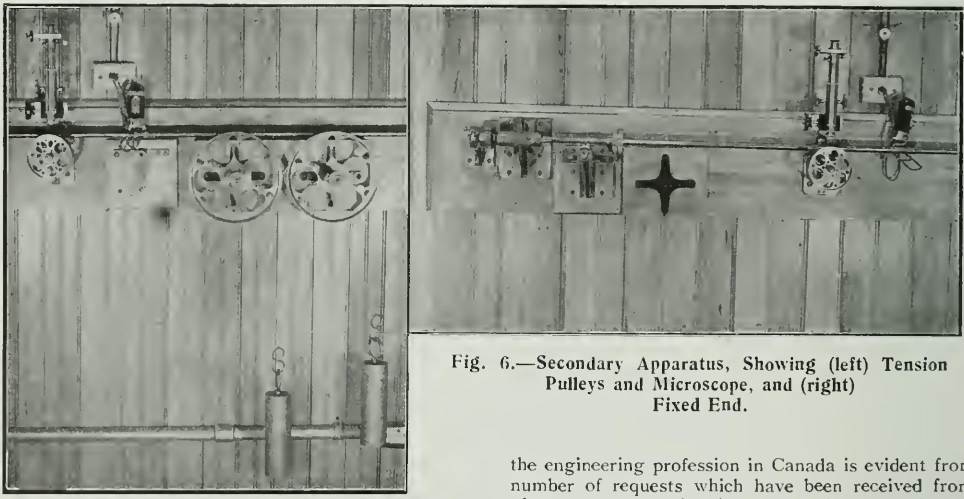

Fig. 6.—Secondary Apparatus, Showing (left) Tension Pulleys and Microscope, and (right) Fixed End.

The construction and method of using this apparatus enables determinations to be made directly for standard temperature. The only possible sources of error in comparisons of this kind would be due to: (1) Variation of temperature; (2) differential sag of tape and standard; (3) friction in the pulleys altering the applied tension. Due consideration was given to these points in the design of the apparatus. Any slight change in temperature affects both tapes to the same degree and may, therefore, be neglected. As the different tapes undergoing test are not all of the same weight per unit length as the standards there is a considerable variation in the sag of the two tapes, very often as much as ¼ in. with 66-ft. tapes supported only at the ends. This difference would cause an error of 0.00082 ft. in the final results unless a correction be applied. To overcome the necessity of using such a correction for varying weights of tapes the intermediate pulleys are used and spaced at such intervals that the alteration in length due to the difference in sag of the two tapes is so small that it may be neglected. After a series of careful determinations, the total friction of one set of pulleys for testing a 66-ft. tape, including end supports, proved to be but .014 lbs. This variation, when testing a 66-ft. tape under 10 lbs. tension, would affect the comparison of the length by less than 2 in 10,000,000.

The method of suspension is so delicate that it was necessary in order to keep the tapes steady during a reading, that the weights be attached to but one end, shown in Fig. 4. The wires imparting the tensions to the tape and standard by means of the attached weights are supported on separate pulleys mounted on ball bearings. The other end of the laboratory standard is fastened to a fixed point and the corresponding end of the tape is attached to a screw in such a way that the tape can be moved lengthwise to enable the various readings to be taken at different parts of the scale (Fig. 7). Horizontal adjustment is also provided to accommodate tapes of varying widths. A steel rod supported by ball bearings extends from one end of the apparatus to the other and when turned it imparts a motion to the adjusting screw by means of small gears. By this means the tapes may be set at any desired reading at any position along the tape-testing apparatus.

During the period in which the apparatus has been in use the results and accuracy obtained are all that could be desired. That a building of this nature is needed for the engineering profession in Canada is evident from the number of requests which have been received from engineers and surveying instrument dealers to have commercial measures verified. Although the building has been in operation but a short time, one hundred and fifty-three tapes have been tested for outside parties at their request.

HUDSON BAY RAILWAY.

The plant engaged on grading and bridge work, track laying and ballasting, for the Dominion Government Railway to Hudson Bay, consists of 3 steam shovels at Pas, and 2 at mileage 110; 13 locomotives; 100 Hart convertible cars and numerous box and flat cars, in addition to 2 passenger cars being operated as far as mileage 110. It is expected to have complete by the end of the year, track laying to the Manitou rapids of Nelson River, and grading from the Manitou Falls to within 110 miles of Port Nelson. Also the foundation work for a large bridge to be built at Manitou rapids, is to be finished this year. In connection with the terminals work in progress at Pas and at Port Nelson, two tracks have been laid at Pas, one from the roundhouse at Eighth Street, and another from the C.N.R., connecting with the bridge across the Saskatchewan River. Eight tracks are to be laid in the yards at once in such a manner that six additional tracks may be added as required. Though the complete details of track laying in the yards has not yet been worked out, it is expected to lay between six and eight miles of track in the yards during the summer. The work in progress at Port Nelson is of a more preliminary character.

SAFETY IN USE OF GRINDING WHEELS.*

Flanges should be of same size, and recessed out from centre, about 1/16 inch deep, for a distance leaving a flat bearing surface near rim of about 1/16 diameter of flange. A compressible washer of blotting paper or rubber, slightly larger than flanges, should be used between flanges and wheel.

Inner flange should be keyed or shrunk on spindle. Accidents have been caused by heavy pieces of work rubbing against a loose inside flange and the brake action caused nut to crawl, and enough pressure was set up by flanges to crush wheel. There should be no dirt between flanges and wheels. Sometimes a wheel breaks because wheel and spindle fit too tight.

It is not necessary to draw the nut up very tight; only enough to firmly grip the wheel between flanges. It has been calculated that on a 1½-inch machine with 8-inch flanges, a man with a 2-foot wrench can easily exert a crushing pressure between wheel and flanges of 3,600 pounds, or over 1½ tons.

If bearings become badly worn, there will be excessive vibration, causing wheel to run out of balance. If bearings are not properly oiled, the spindles run hot and heat is conducted to lead bushing in grinding wheel, and breakage may occur due to expansion of bushing.

Speed recommended by wheel manufacturer should not be exceeded. Under ordinary conditions, wheels will safely stand an overspeed represented by the testing speed. However, wheels may get damaged after being tested, and it is not possible to tell whether a wheel is damaged or not by looking at it. Tapping a wheel a light blow with a small hammer will usually tell if it is damaged, for if the wheel is perfect it will give out a clear ring, but if it is cracked it will have a dead sound.

When there are cone pulleys on a machine, sometimes a loose belt will automatically shift to the small cone pulley, and cause the wheel to run faster than it should. A belt-locking device is a good thing to use on a machine which has cone pulleys.

Most revolving cutters are made of chilled iron and break very easily. A hood on a dresser will catch most of the broken pieces.

Protection hoods provide greater safety than do safety flanges. Protection offered by any given taper decreases with decreased diameter of wheel. To provide equal safety on all sizes of wheels would require, therefore, a graduated difference in taper. A hood with adjustable tongue furnishes equal protection for a wide range in diameter of wheels. A hood adjustable to base of grinding machine also serves same purpose.

Cost of operating a given grinding machine is of importance. Adjustable hoods have the better of the argument, for as the wheel wears, protection flanges must be changed frequently. Such change involves the removal and remounting of the two flanges and wheel; whereas with hood, the change would involve merely setscrew adjustment.

To provide adequate protection for large wheels, the thickness of flanges should be increased beyond those of any flange now on market. This adds momentum to the revolving spindle, which, in turn, would require greater rigidity and strength than is found in the majority of present day grinding machines.

Laws in almost every country and state require removal of dust from dry grinding. This requires a hood, and if a hood is used, it might just as well be strong enough to offer protection in case of accident. A proper hood offers complete protection. Where a hood would interfere with proper use of wheel, a tapered wheel mounted between flanges of a corresponding taper affords the next best method of protection.

*From paper by R. G. Williams, of Worcester, Mass., presented at Chicago convention of American Foundrymen's Association.

PATENTS OF GERMAN AND AUSTRIAN INVENTION.

As provision has been made for the voidance or suspension of patents owned by German or Austrian patentees, a list has been prepared of such patents issued during the month of June, 1914. Those pertaining to engineering and allied industries appear below. A later issue will contain a compilation of such patents issued during the month of July to patentees in these countries.

1. 155947, June 2, 1914, projectile.
2. 155958, June 2, 1914, ball bearing.
3. 155959, June 2, 1914, ball bearing.
6. 156006, June 2, 1914, electric soldering.
7. 156015, June 2, 1914, process of butt-welding rails.
9. 156030, June 2, 1914, firearm.
10. 156066, June 9, 1914, igniter for shells, mines, etc.
11. 156116, June 9, 1914, surface for controlling electrically operated mechanism.
13. 156152, June 9, 1914, piston.
14. 156168, June 9, 1914, pump.
17. 156192, June 9, 1914, glazed mortar coating.
18. 156211, June 16, 1914, steel production.
19. 156212, June 16, 1914, telephone station.
22. 156220, June 16, 1914, apparatus for cooling superheater pipes.
23. 156245, June 16, 1914, cartridge magazine for firearms. Hungary.
26. 156376, June 23, 1914, filter.
27. 156378, June 23, 1914, nitrogen production.
30. 156440, June 23, 1914, electric switch for lamps.
32. 156452, June 23, 1914, wireless telegraphy system.
34. 156498, June 23, 1914, mitering machine.
35. 156506, June 30, 1914, crimping machine.
38. 156537, June 30, 1914, electrolysis of alkali of Halogenes.
39. 156543, June 30, 1914, motor plough mechanism.
40. 156621, June 30, 1914, sound transmitting machine.
41. 156628, June 30, 1914, process of and apparatus for making hollow building blocks.
42. 156630, June 30, 1914, mower and harvester mechanism.
43. 156640, June 30, 1914, cement reinforcement.
44. 156642, June 30, 1914, machine for gauging railway tracks.

Anyone interested may, on payment of a fee of $10 to the Commissioner of Patents, make application to have any one of these patents set aside or suspended. It will be necessary for the applicant to show that he intends to manufacture the invention, and that it is in the interests of Canada, or part of Canada, or of a particular trade, that he should be permitted to manufacture the patented invention. It is within the discretion of the Commissioner, then, to void or suspend the patent.

We are indebted to Messrs. Ridout and Maybee, Toronto, solicitors of home and foreign patents, for the above list.

EFFECT OF ELECTROLYSIS ON THE COMPRESSIVE STRENGTH OF CEMENT AND CONCRETE.

THIS is the subject of a paper read recently at a meeting of the American Institute of Electrical Engineers by C. E. Magnussen and B. Izhuroff, enlarging upon a previous paper entitled "The Electrolytic Corrosion of Reinforced Concrete," presented in 1911. In the earlier paper it was stated that the results obtained were not entirely conclusive, as the experiments were of only 30 days' duration. The series dealt with in the present paper continued for several months and the conclusions corroborate the results reported in the former paper. For the current density covered by the experiments, the current was found to produce no change in the compressive strength of concrete tubes, from which it is deducted that the failures of reinforced concrete due to electrolysis are due entirely to the forces produced by the increase of volume when iron is changed to iron oxide, and not by any direct action of the current upon the concrete.

This series of experiment was begun in September, 1912. Exceeding care was taken to keep the cubes moist. By tightly wrapping them with rubber and friction tape practically all electrical leakage was eliminated, so that all of the current in each circuit was made to pass through the cubes in series.

The tensile strength of the cement used complied with the specifications for standard Portland cement, as given by the American Society for Testing Materials. Chemical analysis and physical test data for this cement are given in Table I.

TABLE I.

Chemical analysis and physical test of the cement.

SiO_2	21 %
AlO_3	7 %
Fe_2O_3	2 %
CaO	66.5%
MgO	1 %
SO_4	0.5%
Na_2O and K_2O	2 %
Specific gravity	3.12%
Fineness:—	
Weight of sample	50.0 gr.
Aver. of 3 sample: retained on 200 mesh..7.9 gr.,	14 %
" " 100 " ..0.29 "	0.58%
" " 50 " ..0.02 "	0.04%
Normal consistency 400 gr. cement 88 gr. water	21.6%
Penetration	10.5%
Tensile Strength:—	
Aver. of 3 sample: 24 hours	108 lb.
7 days	499 "
28 days	717 "

The data from a chemical analysis and specific resistance are given in Table II. for the "fresh water" used.

TABLE II.

	Mg. per l.
Nitrics	0.0
Nitrates	0.0
Free ammonia—a trace	
Albumenoid ammonia	0.0
Free oxygen	0.8
Chlorine	3.5
Total solid	41.0
Fixed solid	21.0

Electrical conductivity per cm^3	at 20° C.	at 30° C.
Cedar River water	20,100 ohms	15,600 ohms.
Fifth normal NaCl solution	54.4 "	45.4 "

The "salt water" used was a 3 per cent. NaCl solution in the above water.

Natural sand, screened to pass a sieve having 20 meshes per linear inch and retained on a sieve having 30 meshes, was used.

The gravel was screened to pass a sieve having 4 meshes per linear inch, and retained on a sieve having 8 meshes.

Two hundred and forty 2-inch (5-cm.) cubes were made as follows:

(a) Sixty cubes of cement with "fresh water."
(b) Thirty-six cubes of mortar with "fresh water." Ratio of cement to sand, 1:3.
(c) Twenty-four cubes of concrete with "fresh water." Ratio of cement : sand : gravel = 1 : 1 : 1.
(d) Sixty cubes of cement in "salt water."
(e) Sixty cubes of concrete in "salt water." Ratio of cement : sand : gravel = 1 : 1 : 1.

The cubes were made in accord with the specifications of the Committee on Uniform Testing of Cement, American Society of Civil Engineers.

Six bronze molds were used and six cubes were made at a time, and in the tables this is termed a "set." In making the cubes due care was taken to secure uniform conditions. The consistency was adjusted to give a reading of ten on the scale of a Vicat needle. The cubes were kept in the molds under cover of a damp cloth, to keep the air moist for 24 to 28 hours. At removal from the molds each was numbered, and then immersed in water "fresh" for groups (a), and (b), and (c), and "salt" for (d) and (e), where they were kept for forty to sixty days.

Four cubes from each set were then placed in the electric circuit; No. 1 nearest the anode, next No. 2 and No. 3 with No. 4 nearest the cathode. The remaining two cubes, No. 5 and No. 6, were kept in the water as control. As the four cubes in the electric circuit were kept moist throughout the experiment the only factor affecting cubes No. 1-4 more than No. 5-6 would be the electric current passing through the former.

The arrangement of the cubes and the wiring are shown in Fig. 2. At each end an iron plate was placed, extending a little beyond the surface of the cubes, and having a copper wire soldered to one edge for electrical connection. A glass plate and a rubber strip were placed outside the iron for insulation and the whole secured by a wooden clamp. By means of this clamp pressure could be applied so as to give a fairly good contact between the iron plates and the cubes, and also to bring the four cubes into close contact. The sets were wrapped tightly with rubber tape, and this secured by friction tape. In order to keep the cubes moist small openings were made through the tape on top of the cubes. These openings were covered by inverted test tubes, full of water, salt or fresh according to which had been used in making the cubes. See Fig. 1. Absorbent cotton was placed under the test tubes and in this way the water could slowly seep through the cotton and keep the cubes moist. A storage battery of 60 cells in series with a lamp bank was connected to the iron plates. The voltage was applied continuously.

The currents in the circuits were characteristically irregular. The iron plates corroded at the anode ends of all the sets. In the salt water sets the corrosion was much more rapid than with the fresh water cubes. The cotton under the test tubes near the anode became saturated with the iron oxide. In the salt water sets the dis-

coloring appeared in a few hours, while with the fresh water three or four days were required. In set No. 7 the cotton was colored a greenish blue or Fe_3O_4, while all of the rest showed the red color of Fe_2O_3.

No odor was noticeable from the fresh water cubes. The chemical reactions probably consist simply of a decomposition of water and the formation of iron oxide.

$$3\ H_2O \longrightarrow 6\ H + 3\ O$$
$$3\ O + 2\ Fe \longrightarrow Fe_2O_3$$

No tests were made to determine a possible migration of sulphates and other salts.

An odor of chlorine accompanied the reactions in the salt water sets. The following equations give the main reactions:

$$4\ NaCl \longrightarrow 4\ Na + 4\ Cl$$
$$4\ Cl + 2\ H_2O \longrightarrow 3\ H\ Cl + H\ ClO + O$$
$$H\ Cl\ O \longrightarrow H\ Cl + O$$
$$2\ Fe + 3O \longrightarrow Fe_2\ O_3$$
$$Fe_2O_3 + 6\ H\ Cl \longrightarrow 2\ Fe\ Cl_3 + 3\ H_2O$$

The chlorine odor indicates the presence of hydrochloric acid and this may cause a secondary reaction that might affect the crushing strength of the cubes.

Testing Cubes.—Finally, the cubes in the electric circuit and the controlling cubes were tested for their compressive strength, using a Riehle 60,000-lb. testing machine. All cubes were tested under as nearly identical conditions as possible, using the same machine and at the same speed. One half of the tested cubes was crushed in the direction of the flow of the current, and the other

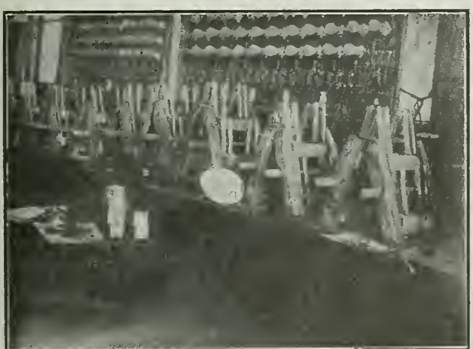

Fig. 1.—Arrangement of Test Apparatus.

half was tested in direction perpendicular to the flow of the current. (Fig. 3). One half of the control cubes was crushed in the direction of the open ends of the bronze mold and the other half in the direction of the sides of the mold.

Summary.—(*a*) The compressive strength of fresh water cement cubes was not affective by an average current density of 1.2 milliamperes per square inch (0.17 milliampere per cm^2) applied for 310 days.

(*b*) The compressive strength of fresh water concrete cubes was not affected by an average current density of 1.8 milliamperes per square inch (0.26 milliampere per cm^2) applied for 225 days.

(*c*) The compressive strength of salt water cement cubes was probably not affected by an average current density of 10.2 milliamperes per square inch (1.4 milliampere per cm^2) applied for 113 days.

(*d*) The compressive strength of salt water concrete cubes was not affected by an average current density of 13.8 milliamperes per square inch (1.9 milliampere per cm^2) applied for 110 days.

For (*a*), (*b*), (*d*) the average values for the cubes treated with the electric current were 1, 2, 3.0 and 2.5 per cent. respectively stronger than the corresponding control cubes. For group (*c*) the cubes in the electric circuit were 14 per cent. weaker than the control. An examination of the crushing strengths shows that the ap-

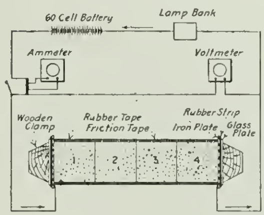

Fig. 2.

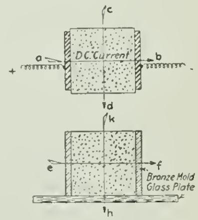

Fig. 3.

parent decrease is most likely due to a chance selection of too many of the stronger cubes for the control. If any action were due to the current the liberated chlorine would be the most likely agent. Since the chlorine is liberated at the positive pole it would appear at cube No. 1. In sets No. 22 and No. 23, the cube No. 1 was weakest, but in sets No. 27 and No. 29, cube No. 1 was strongest. Moreover, cube No. 1 in set No. 29 was the strongest in the whole series and hence not likely to have been weakened by the current. The series shows less uniformity in strength than the cubes in either (*a*), (*b*) or (*c*).

Averaging the averages for the four groups, the strength of the cubes Nos. 1, 2, 3 and 4 was only 1.8 per cent. less than the control cubes Nos. 5 and 6; and this difference is well within the errors of the experiment.

Summarizing the results, we find that for the current density covered by the experiments the current produces no change in the compressive strength of the cubes. This is in accord with the preliminary observations in the earlier paper (A.I.E.E. Trans. XXX., p. 2067).

Within the limits of current density for which these conclusions apply, it follows that failures in reinforced concrete due to electrolysis are due entirely to the forces produced by increase in volume when the iron is changed into iron oxide and not by any direct action of the electric current upon the strength of the concrete.

Messrs. Hering and Fuller, consulting engineers, of New York, made a periodical inspection of the filtration plant under construction at Montreal last week. It is reported that the proposed extension, which the Board of Control intends to carry out next year, was also under consideration.

A new process of manufacturing white lead is being tried out in the United States, and is being watched with interest by Canadian paint manufacturers and engineers who have occasion to specify lead paints. It is called the Euston Process, and is followed by the Euston Process Co., Scranton, Pa. Mr. Euston claims his lead has great uniformity, smoothness, tenacity and opacity; that it is non-checking, adhesive and durable. The particular advantage of this process seems to be the rapidity with which the lead can be manufactured compared with older methods.

PHOTOGRAPHIC SURVEYING.

THE photographic method of surveying is sometimes known by the names phototography and topophotography. The principle is to measure by means of perspectives, usually photography. The conception of this method is due to Laussedat (Austria). His first experiments, according to Dr. Deville's book on the subject, were made in 1849, the perspectives being drawn with a camera lucida. Shortly after, he substituted photography for the camera lucida. Wherever photographic surveys are now made, they are executed by the application of the principles laid down by Laussedat.

It is in Canada that the method has received its most extensive application; it was first employed when the surveys of Dominion lands were extended to the Rocky Mountains. In the prairies, operations are limited to defining the boundaries of townships and sections; these lines form a network over the land by means of which the topographical features, always scarce in the prairies, are sufficiently well located for general purposes.

In passing to the mountains, the conditions are entirely different. The topographical features are well marked and numerous; the survey of the section lines is always difficult, often impossible, and in most cases useless. The proper administration of the country required a tolerably accurate map, and means had to be found to execute it rapidly and at a moderate cost. The ordinary methods of topographical surveying were too slow and expensive for the purpose; rapid surveys, based on triangulations and sketches, were tried and proved ineffectual; then photography was resorted to.

Up to 1892, the photographic surveys were confined to the Rocky Mountains, in the vicinity of the Canadian Railway; at the end of that year, they covered about 2,000 square miles. In the same year, an International Boundary Commission was appointed to examine the country along the boundary between Canada and the United States territory of Alaska. The Canadian Commissioner, Mr. W. F. King, decided to carry out his share of the work by photography. In 1893 and 1894, his parties surveyed about 14,000 square miles.

Irrigation surveys were commenced in the south-westerly part of the North-west Territories, where the rainfall is not quite sufficient for agricultural purposes. In addition to the gauging of streams, the establishment of bench marks, etc., it is necessary to ascertain the catchment areas and to define the sites best adapted for reservoirs. For this purpose photography has again been resorted to in the foot hills and on the eastern slope of the mountains. It has, in this case, a peculiar advantage. Whether or not a site is a favorable one for a reservoir cannot be known until the plan has been partly plotted. It must be possible to bring water to the proposed place and to run it off; the capacity must also be adequate. If favorable, a detailed survey of the site is required. With the ordinary surveying instruments, a preliminary survey has to be made; if, after plotting it, the site is found favorable, the topographer has to go over the ground a second time to make a detailed survey. Or, the whole of the work may be executed at once, with the contingency that the detailed survey may turn out useless. With the camera, the plan may be plotted so far, and so far only, as required; the photographs which furnish a general plan can be made to give all the detail wanted without going again into the field. Whether the site is a good one or not, there is no labor wasted.

Notwithstanding the many publications on photographic surveying, the great advantages assigned to it and the numerous experimental surveys executed, it has not yet come into general use; in many quarters there is still an adverse feeling against it. There is such a fascinating simplicity about the method that it is at first difficult to understand the reasons which prevent its adoption. Can anything more convenient be conceived than a method which enables a topographer to gather rapidly on the ground the material for his maps and to construct them afterwards at leisure in his office?

Dr. Deville in his book says: "Assuming that the plane table can be used in the field whenever the weather is fair enough for the camera, which is not always the case, also that the topographer can plot and draw in the field as quickly as in the office, where he has every convenience at hand, the same survey by the plane table would require the same length of time at actual work or four days. To this we must add four days lost on account of the weather, or eight days altogether.

"The cost of our parties in the field is $20.50 per diem; at office work the only expense is the salary of the topographer, $5.00 per diem. Summing up, we find the comparative cost as follows:

Plane Table—	
8 days in the field, at $20.50 per diem	$164.00
Camera—	
2 days in the field, at $20.50 per diem	$ 41.00
3 days in the office, at $5.00 per diem	15.00
	$56.00

"This shows that the plane table survey would cost at least three times as much as the camera survey. In reality, the difference is greater, because part of the work, as well on the ground as in the office, is executed by the assistant, an arrangement which cannot very well be made with the plane table. The figures above are derived from our practice; with more views or more detailed plotting, the difference in cost would be still more in favor of the camera.

"If we analyse the causes of the superiority of the camera, we find that a very small portion of the topographer's time is spent in surveying operations. Nearly the whole of it is devoted to travelling for the purpose of seeing the country and he can map all that he, or rather his camera, can see. His work consists of two distinct parts; on the ground he simply collects data, and, with the exception of a few angles, does not waste any of his time in plotting or making measurements. This is left for the office, where the only expenses are the salaries of the surveyor and assistant. In the next place, the party consisting of an assistant and two men is, if not smaller, at least as small and inexpensive as for any other kind of survey. One man is sufficient to carry our camera and tripod almost anywhere, while an ordinary plane table, if it could be taken where our camera has been, could not be carried there by any single man.

"It is objected that plotting from photographs is more laborious than plotting on the plane table. There is, indeed, a slight additional labor; against this may be set off the fact that no useless line is ever drawn, as when, on the plane table, a point is sighted upon which cannot be recognized from the next station. The greater convenience of working in an office, instead of in the open air, turns the scale in favor of the camera. But photography has an overwhelming advantage in the numerous processes which the laws of perspective place at the disposal of the topographer. The plane table cannot compete with the perspectometer or the perspectograph.

"Another objection is, that points cannot be so easily identified on photographs, nor the forms of the surface

so truly represented, as when the topographer has the ground under his eyes. This is a mistaken idea; there is no difficulty whatever in identifying any number of points on moderately good photographs, and, moreover, the topographer does not need, as with the plane table, to trust to his memory in order to recognize them. The undulations of the ground are, it is true, less distinct on the photographs, but this is more than compensated by the advantage of having, side by side, views of the same place from several stations."

Surveying Cameras.—The number of instruments devised or proposed for photographic surveying is considerable. They are divided into three classes:—

(1) Ordinary cameras.
(2) Surveying cameras or "photogrammeters."
(3) Photo-theodolites.

Ordinary cameras must be provided with a level; the relative positions of the plate and lens must be invariable, and when adjusted, the plate must be exactly vertical.

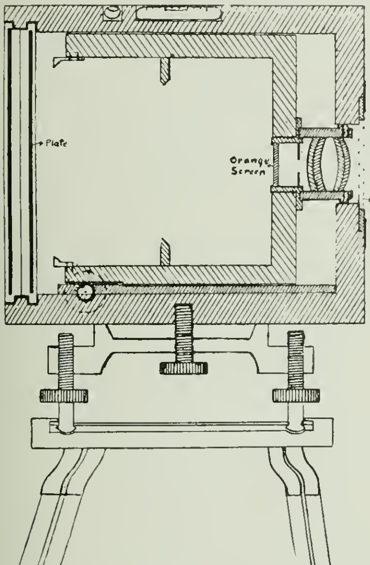

Fig. 1.—Sectional View of the Deville Surveying Camera.

The horizon is determined by two zenith distances of well-defined objects as far apart as possible. The principal points are ascertained from the azimuths of at least three points. It is expedient to make these determinations for every photograph. See specimens of plotting Figs. 2 and 3 (Wheeler).

The employment of ordinary cameras for surveying is not recommended. The present Surveyor-General, Dr. Deville, has invented a camera suitable for this work. A section of this camera is shown in Fig. 1. There are, however, many patterns of surveying cameras, one of the earliest is Meydenbauer's. It is a camera with tapering bellows set on a horizontal circle: it moves on a vertical axis.

Canadian Equipment.—The equipment of a party on the Canadian Surveys consists of a transit theodolite and two cameras. The transit theodolite and its tripod are carried by the surveyor, and a camera without the tripod by one of the men who always accompanies the surveyor. The assistant has his own camera with a tripod.

The transit is one of the ordinary patterns used by surveyors. It has three inch circles and reads to minutes. The tripod is a short one, specially designed for mountain work. It is three feet four inches long and has sliding legs, the joint being perfectly stiff. The surveyor observes

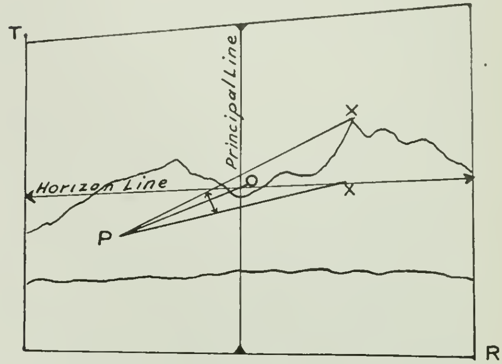

Fig. 2.

either in a sitting or kneeling position. For the purpose of packing, the head of the tripod is taken off and put in the transit box; when folded, the legs are twenty inches long and are placed under the box of the transit, as shown in frontispiece. The heavy parts of the instrument are made of aluminum; the whole, including tripod

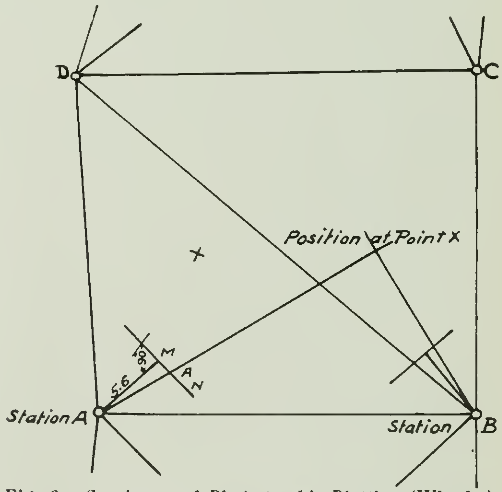

Fig. 3.—Specimens of Photographic Plotting (Wheeler).

and case, and also the camera base, weighs fourteen pounds and eight ounces.

Plotting the Survey.—The minutes of Canadian surveys are plotted on a scale of 1/20,000. They are afterwards reduced for publication to 1/10,000. The equidistance is 100 feet.

The angles measured are equal to those on the ground, for any triangle ABC of the ground is represented on the model by a similar triangle *a b c*. The altazimuth set in *a* gives between *b* and *c* the same angle as it would between B and C, if set at A.

Thus, if the plan be required on a scale of 1/20,000, the model is assumed to have been reduced to that scale, and the problem consists in making a plan full size by means of angles and photographs obtained on the model.

No change being made to the camera, the focal length preserves the same value; if one foot, it covers on the model a distance corresponding to 20,000 ft. on the ground. A distance of a mile contains 5,280 ft. on the ground, and is represented on the model by 5,280 "scale feet."

The focal length of one foot mentioned above would be a focal length of 20,000 "scale feet." It follows that, although the problem consists in representing a model full size, the scale may be employed to measure the actual dimensions, the value of one division being considered as an arbitrary unit.

In plotting, the primary triangulation is assumed to have been previously calculated; the primary stations can therefore be plotted at once by their co-ordinates. For example, the camera station has been observed from one or more triangulation points. A camera station, M, having been observed from a triangulation point A, triangles may be formed with M, A, and other triangulation points observed both from A and M, such as B. In the triangle MAB, the angles at M and A have been observed, and $B = 180^\circ - (A + M)$. Similar calculations made for other triangulation points give the directions of the station as seen from these points; the plotting is done as if the station had been observed from every such point.

From the foregoing it is evident that the surveyor should endeavor to obtain at least one direction from a triangulation point on every camera station; the plotting is less laborious and the result more accurate.

Contour Lines.—A sufficient number of heights having been determined, the contour lines are drawn by estimation between the points established. In a rolling country a limited number of points is sufficient to draw the contour lines with precision, but in a rocky country the reflections on the surface are so abrupt and frequent that it is utterly impossible to plot enough points to represent the surface accurately. Every point, however, plotted has been marked on the photograph, and the altitudes may be taken from the plan.

Precision of the Method of Photographic Surveying.—The precision of a survey executed by the methods exposed, when all the points are established by intersections, is the same as that of a plan plotted with a very good protractor or made with the plane table. There is, however, this difference: the number of points plotted by photography is greater than by the other methods.

Points plotted by means of their altitude below the station are far less accurate, their positions being given by the intersection of the visual ray with the ground plane, the angle of intersection being equal to the angle with the horizon plane or to the angle of depression of the point. With the camera employed, embracing 60°, this angle is always less than 30°; even that is seldom obtained in practice, a declivity of 30° being almost a precipice. Therefore, the intersection is always a poor one and the uncertainty becomes considerable with points near the horizon.

With perspective instruments, doing mechanically the same construction, the results are still less precise, being affected by the instrumental errors.

On the other hand, it must not be forgotten that when these methods are employed, the ordinary topographer would fall back on sketching; the results furnished by topography are therefore indefinitely more precise.

UNITED STATES PRODUCTION OF EXPLOSIVES.

As explosives are essential to mining, and the use of improved types of explosives lessens the dangers of mining, the U.S. Bureau of Mines undertook the compilation of information showing the total amount of explosives manufactured and used in that country, its first report dealing with the year 1912. It now issues the second technical paper relating solely to the production of explosives. It is expected that similar publications will be compiled annually, and that with the co-operation of the manufacturers these statements will be published within a few weeks after the end of each year.

The figures show that in 1902 only 11,300 pounds of permissible explosives was used in coal mining, whereas in 1913 the quantity so used was 21,804,285 pounds. The quantity of permissible explosives used in the United States is larger than in a number of other countries. In 1912 it represented about five per cent. of the total quantity of explosives produced, and in 1913 six per cent. The total amount of explosives used for the production of coal in 1913 was 209,352,938 pounds, of which about ten per cent. was of the permissible class as compared with eight per cent. in 1912. The use of permissible explosives in coal mining has had gratifying results, and few, if any, serious accidents can be attributed directly to their use.

The total production of explosives, according to the figures received from manufacturers, was 463,514,881 pounds in 1913, as compared with 489,393,131 pounds for 1912. This production is segregated as follows: Black powder, 194,146,747 pounds; "high" explosives other than permissible explosives, 241,682,364 pounds; and permissible explosives, 27,685,770 pounds. These figures represent a decrease of 36,146,622 pounds of black powder and an increase of 7,212,872 pounds of high explosives and 3,055,500 pounds of permissible explosives.

NOVEL POWER DEVELOPMENT SCHEME.

A method of producing power from sea water by the rise and fall of the tides is proposed. Portions of the coast where high tides are the rule are chosen and a number of clefts in the cliffs are constructed or those of nature especially adapted. The water runs far into the openings at high tide and by means of pipes is trapped into a huge reservoir. Where the tide falls hundreds of gallons of water are thus left behind. Being on a high level it is then a comparatively simple matter to drop this water by means of pipes to a level many feet below and utilize the power thus obtained by the usual water jets acting on specially constructed wheels.

The latest statistics regarding the development of wireless telegraphy in the German Empire are up to the beginning of 1913. At the beginning of that year there were 23 coast stations and 376 ship stations. Of the coast stations, 12 were open to general traffic, 10 with limitations, and 1 for official use. Of the ship stations, 237 were for public, 134 for official, and 5 for private traffic. The number of wireless telegrams sent from the shore to the ships in 1912 was only 5,312; in the contrary direction, 14,893. Between ships 7,242 telegrams were exchanged. This makes a total traffic in telegrams of 27,447. Receipts for the year totalled 250,000 marks. In these figures the German Protectorates are included.

THE MAKING OF SOUND STEEL INGOTS.*

By Bradley Stoughton, Ph.B.,
Consulting Metallurgical Engineer, New York, N.Y.

THE metallurgist of to-day bears almost the same relation to steel as a doctor does to his patient. Where formerly a simple examination and a small number of tests completed a diagnosis, to-day the physician investigates the physical life history of the patient, together with some matters in the physical life of his parents and grandparents. The metallurgist also is not now content with the condition of the steel as revealed by mechanical and physical test, but wants to be informed as to its life history during manufacture, and as to the quality of pig iron from which it was made and the conditions prevailing during the conversion and during the the manufacture of the pig iron itself.

It is comparatively easy to tell by the usual tests whether the structure and composition of steel attain a given standard or quality, but certain dangerous defects, which may be inherent in the metal, will often escape the customary inspection, and may be difficult to discover even by such extraordinary investigations as sulphur-prints, microscopic examination, hardness tests, shock tests, etc., unless these are carried on at such an extensive scale as to destroy the steel for service. Defects of this character are generally classified under the head of unsoundness, and the chief ones may be described as follows:—

1. Presence of blow-holes;
2. Presence of combined and occluded oxides;
3. Presence of an unwelded shrinkage cavity; and
4. Excessive segregation.

The most effective means of preventing these elements of unsoundness is the exercise of great care and watchfulness during the manufacture of the steel, and also during the manufacture of the iron from which the steel was made, because it now seems to be removed practically beyond controversy that certain unfavorable conditions during the smelting of iron ores in blast furnaces will produce a grade of pig iron which, during the ordinary process of manufacture, will be converted into an unsatisfactory grade of steel. It is not our purpose to discuss this matter at length in this paper, but the literature on cast iron during the years 1913 and 1914 will afford ample proof of the accuracy of this statement. Fortunately, careful and expert inspection of the manufacturing process, and suitable testing of the product, are sufficient to prevent steel of this undesirable quality going into service.

Expert care and inspection during the manufacture and rolling of steel is also the best safeguard for preventing unsound metal from any of the other causes mentioned above going into the service of the consumer. Steel that is dangerously filled with blow-holes, or which is badly segregated, will give some indications of this condition during the ingot-forming or rolling stages. The presence of a residual unwelded shrinkage cavity can usually be prevented by proper inspection during cropping, although this is not an infallible safeguard. Oxide inclosures result from improper conditions of manufacture during the conversion of ingot-forming stages, such as: too late addition of ore to the open-hearth furnace; improper composition of the final open-hearth slag; insufficient fluidity of metal; wildness; excessive or improper addition of deoxidizers in the melt, etc.

The subject of prevention of oxide inclusion has received a good deal of attention from several eminent investigators during the past two years, and a number of remedies have been suggested. The most effective means which has been extensively applied during manufacture is the addition to the liquid bath of steel of properly proportioned quantities of titanium alloy.

Segregation does not occur to a dangerous extent when the phosphorus and sulphur are reduced to reasonable limits, provided the steel is properly deoxidized before teeming; is not wild in the moulds, and is poured in ingots not exceeding 5 to 10 tons each in weight. The larger the ingot, the smaller should be the proportion of sulphur and phosphorus in the steel, and ingots of very massive sections should not be used, unless the central core is to be drilled out and discarded, as is the case in the manufacture of large guns, for example.

The presence of blow-holes is not dangerous in low-carbon steels, except in certain situations, the causes for which are now well understood and can be eliminated. In medium and high carbon steel, the presence of blow-holes will always be indicated by the action of the liquid metal in the moulds, and suitable care in manufacture forbids such material going further in the manufacturing process. The careful steel-maker sends it at once to the scrap pile.

The prevention or elimination of the shrinkage cavity in steel ingots and castings without prohibitive expense, or equally prohibitive complication in manufacture, has taxed to the utmost the ingenuity of metallurgists, and many hundreds of thousands of dollars have been spent in experiments and investigations of numerous schemes and inventions. For many years the compression of the ingot during the process of solidification, in order to reduce the size of its outer envelope and thus compensate for the shrinkage taking place during solidification, has been practised at steel works where steel of the highest quality is made. The expense of this compression process, consisting of interest on investment, complication in the process of manufacture, and cost of operation, is not wholly compensated for by the lesser proportions of the ingot which has to be converted into scrap. The compression during solidification is also claimed to improve the strength of the metal, and this claim, although not granted by all metallurgists, has some practical evidence in its favor.

An English and an American investigator have used the compression process for elimination of the pipe in a way which aims to eliminate interference with the manufacturing process and interest on the investment, by taking the steel ingot before it has completely solidified and reducing its section in an ordinary pair of blooming rolls; then returning it to the heating furnace until entirely solidified, and subsequently completing the rolling operation in the usual way. Other recent investigators have aimed to accomplish a reduction in the cost of treating the steel by substituting some other method for the compression process, but none of these newer inventions secures the elimination of the shrinkage cavity, but only its reduction to a smaller size or a greater concentration at the top of the ingot, with consequent smaller proportion of cropped-off metal being necessitated.

Sir Robert Hadfield burns charcoal on top of the steel ingots in a special mould with a sand top, so as to delay the cooling of this portion of the metal and consequently draw the shrinkage cavity to that point.

*From a paper read before the Mining and Metallurgical Section of the Franklin Institute.

Emil Gathmann, by a very ingenious method of casting ingots with the smaller end down and then stripping them without excessive inconvenience, as well as by distributing the metal in his ingot moulds, also produces a more rapid cooling of the lower parts of the ingot than of the top, and thereby concentrates the cavity in the upper portion.

The Goldschmidt process involves heating the metal in the top of the ingot by the well-known thermit reaction, or else by creating a stirring reaction in the ingot by means of a can of thermit through which, it is claimed, blow-holes, pipes, and segregation are all reduced.

Each of these cavity-reducing processes has been tried on a commercial scale long enough to prove its advantage under a given set of conditions. It is probable, however, that, in the production of very large quantities of steel, cropping off as much of the ingot as is necessary to remove the shrinkage cavity is cheaper than introducing a complication into the process of manufacture, and that careful inspection is an adequate safeguard for avoiding the dangerous defect in finished steel known as an unwelded pipe in the great majority of cases.

FOURTH AMERICAN ROAD CONGRESS.

Final arrangements for the Fourth American Road Congress, to meet in Atlanta, Georgia, during the week of November 9-14, are nearing completion. All indications point to a record-breaking attendance and exceptionally strong program, while the demand for exhibit space on the part of manufacturers will far exceed the supply of space available.

The Construction and Maintenance Section program as now made up is as follows:

Drainage Structures.—By W. F. Atkinson, state highway engineer of Louisiana. Discussion opened by S. D. Foster, chief engineer, State Highway Department of Pennsylvania.

System in Road Management.—By C. J. Bennett, Highway Commissioner of Connecticut. Discussion opened by Paul D. Sargent, state highway engineer of Maine.

Maintenance Methods and Relation to Traffic.—By George W. Cooley, state engineer of Minnesota. Discussion opened by H. R. Carter, state highway engineer of Arkansas.

Convict Labor.—By George P. Coleman, state highway commissioner of Virginia. Discussion opened by J. E. Maloney, state engineer of Colorado.

Rights of Way.—By Austin B. Fletcher, highway engineer of California. Discussion opened by W. S. Gearhart, state engineer of Kansas.

Surfaces for Light Volume Mixed Traffic.—By S. Percy Hooker, state superintendent of highways of New Hampshire. Discussion opened by Frank F. Rogers, state highway commissioner of Michigan.

Efficiency in Highway Organization, Centralization of Purchases.—By E. A. Stevens, state highway commissioner of New Jersey. Discussion opened by John S. Gillespie, Road Commissioner of Allegheny County, Pennsylvania.

State Control of Road Work as a Policy.—By A. N. Johnson, former state highway engineer of Illinois. Discussion opened by T. H. MacDonald, state highway engineer of Iowa.

Engineering Supervision of Road Construction.—By W. S. Keller, state highway engineer of Alabama. Discussion opened by R. C. Terrell, state highway commissioner of Kentucky.

Economics.—By J. E. Pennybacker, chief, Division of Economics, U.S. Office of Public Roads.

Educational Field for Highway Departments.—By Dr. Jos. Hyde Pratt, state geologist of North Carolina. Discussion opened by Col. Sidney Suggs, state highway commissioner of Oklahoma.

Heavy Traffic Roads.—By Henry G. Shirley, chief engineer, State Roads Commission of Maryland. Discussion opened by W. A. Hansell, superintendent of public roads, Fulton County, Georgia.

Grades and Excavation.—By A. D. Williams, chief road engineer of West Virginia. Discussion opened by Wm. R. Roy, state highway commissioner of Washington.

Problems of Street Construction and Maintenance.—By Charles E. Bolling, city engineer, Richmond, Virginia. Discussion opened by F. L. Ford, city engineer, New Haven, Conn.

Road Binders and Palliatives.—By chief engineer, Rhode Island State Roads Commission. Discussion opened by Chas. W. Campbell, city engineer, St. Joseph, Mo.

Possible Lines of Improvement in Contract Highway Work.—By John J. Ryan, secretary, New York State Road Builders' Association. Discussion opened by L. D. Smoot, city engineer, Jacksonville, Florida.

The elaborate exhibit of the U.S. Office of Public Roads, which is being prepared for the Panama-Pacific Exposition, will be shown intact at the Road Congress and will include not only exact models of every known type of road, and the historical development of road building from the earliest times, but will also comprise special models showing road location, the beautifying of the roadside, and mountain road construction as exemplified in the splendid Swiss roads. The New York State exhibit will include at least one example of model work, which it is claimed will prove one of the most impressive exhibits at the Congress. A number of other states will have interesting exhibits in the form of models, maps and materials.

Information about the program and the Congress in general may be obtained from I. S. Pennybacker, Executive Secretary, and concerning exhibits from Charles P. Light, Business Manager, Colorado Building, Washington, D.C. The general officers of the Congress are as follows: Austin B. Fletcher, State Highway Engineer of California, president; Edward M. Bigelow, State Highway Commissioner of Pennsylvania, vice-president; W. E. Atkinson, State Highway Engineer of Louisiana, 2nd vice-president; A. N. Johnson, Former State Highway Engineer of Illinois, 3rd vice-president; C. A. Magrath, Chairman, Ontario, Canada, Highway Commission, 4th vice-president; Lee McClung, treasurer, former treasurer of the United States; John N. Carlisle, State Commissioner of Highways of New York, Chairman, Committee on Program; the Executive Committee comprises in addition to President Fletcher, George C. Diehl, Chairman, Good Roads Board, American Automobile Association; Logan Waller Page, President, American Highway Association and Director, U.S. Office of Public Roads; Richard H. Edmonds, editor of the Manufacturers' Record, and A. G. Batchelder, Chairman, Executive Committee, American Automobile Association.

Editorial

THE TORONTO-OSHAWA ROAD.

The construction of roads and the relief for the unemployed are phrases that accompany each other in the minds of the general public to such an extent nowadays as to be safely ranked as synonymous. From all parts of the Dominion we learn that there is talk of certain highway improvements in order to provide employment for the out-of-works. No doubt as the severity of winter sets in many Canadian towns and cities will regret that their good intentions did not materialize more substantially. It is a fact, nevertheless, that a great deal of time has been spent in promoting such enterprises and in overcoming quibles of one kind and another, that have resulted. It is now over two months, for instance, since the Hamilton-Toronto highway was quoted as being an assured fact and that little remained but to place the laborers at work. No work has been provided, however, and the approach of November is a stern reminder that the season for such work is practically at an end. Insofar as the unemployed are concerned, the municipalities interested can depend but little upon the proposed highway as an immediate work-providing channel, and they must therefore look elsewhere, to remedy the condition of the dinner-pail.

The regrettable delay in the above instance is more or less typical of similar delays elsewhere. It appears that, in the majority of cases the cause for dalliance has been the same—the opposition which some town or city council puts in the way, owing to a small detail or two being apart from its liking. Thomas A. Edison, the inventor, speaking last week at Chatham, Ont., in commenting upon the large numbers of unemployed, strongly endorsed the suggestion of the governmental building of trunk roads through the country. Besides affording employment during the period of industrial paralysis, brought on by the war, the roads thus built would be of inestimable value to the communities through which they would pass. Mr. Edison's advice, we are afraid, has fallen upon already well-informed ears. What the country needs most is a practical working out of a system whereby a proposal of this kind, so undoubtedly of great need in more ways than one, may be got under way before the season for the undertaking is over.

While the Toronto-Hamilton highway scheme is still impaled on the barbs of opposition to technicalities, with evidence of little or no progress this fall, there is an abundance of interest associated with the proposal of a permanent highway east from Toronto to Oshawa. A municipal deputation has been to the government asking for an immediate survey, an estimate of the cost, with a suggested assessment on each municipality. A 16-ft. concrete road with 4-ft. gravel shoulders is mentioned, and an alternative estimate for a macadamized road is asked.

Although the Premier held out no immediate hope, as the present time is fraught by a number of difficulties in the way of raising money, he approved of the scheme on behalf of the government and stated that upon the realization of relief, which is expected early in the shape of a Federal grant for provincial highways, the matter would be proceeded with.

Further, the new Minister of Public Works assured the municipalities that the Department of Highways would make an immediate survey of the route and would shortly provide them with plans and estimates.

DEVELOPMENTS IN ELECTRIC TRACTION.

The entrance of electric power into the domain of the steam locomotive began in the early nineties with small trains in passenger service. Chicago, in 1893, where motor cars were used as electric locomotives, initiated in America the permanent invasion of the extensive steam service on elevated lines.

The earlier applications of electric power to regular steam railway service were in most cases for service in tunnels and railway terminals, with the object of eliminating the smoke and gases common to the use of steam locomotives. The Baltimore & Ohio Tunnel which commenced operation in 1895 was the first instance of electrification as applied to heavy traffic, and the first electric locomotives to successfully initiate the struggle for supremacy with steam locomotives under main line requirements.

"The electrification of main line service," states Mr. W. B. Potter, chief engineer, railway and traction department, General Electric Company, in the General Electric Review, "is no longer an experiment. The heaviest traffic can be successfully handled, and therefore there remains only the question of whether it will pay. As a rule, excepting the expense incident to the initial investment, the cost of operation with electric power will be less than with steam, and often this saving will show a handsome return on the investment. There are many instances, such as tunnels and terminals, where other considerations than the financial showing are of paramount importance. Even in such instances there are often local conditions where the value of property will be enhanced, or where territory necessary to steam service can be made available for other purposes and therefore remunerative.

"The possibility of handling heavier, or even equal trains at higher speeds is becoming better recognized as a means of increasing the tonnage over a given route, and so provide for an increasing traffic more economically than by the construction of additional lines under steam operation."

Electric locomotives for heavy traffic must be so constructed as to withstand the severe shocks and strains which occur in the handling of trains, and to facilitate inspection and maintenance the electrical and other equipment should be conveniently located. Much attention has been given to the development of different general types, and many varieties of electric locomotives differing both in mechanical design and electrical equipment have been built and tested.

Variations in the mechanical construction are influenced largely by different methods of transmitting the power from the electric motor to the driving wheels. The motor car and steam locomotive have both served as models, with innumerable variations in which their characteristics have been differently combined and in many cases with indifferent success. Geared or gearless motors mounted on the driving axle, or in special cases a combination of gearing and parallel rods, each with reference to its fitness for the particular purpose, are the most promising methods of drive. Guiding trucks will undoubtedly be used in high-speed service and doubtless at slower speeds with very heavy locomotives where the weight distribution on the track may be of importance.

The character of electrical equipment, considering the larger power required in main line service, is influenced by the problem of electric transmission to the locomotive and the collection of current from the conduction circuit. As the amount of current varies inversely as the voltage, the transmission and collection are therefore made easier at higher potentials. The development of equipment suitable for higher voltages has received much attention, and there are at present a number of important railway electrifications of this character on which alternating or direct current is used. The respective merits of alternating or direct current involve many details of which a very few are of general interest as influencing the trend of commercial development. As between the different systems the indications point strongly, however, toward the more general adoption of direct current for main line electrification and heavy railway service generally.

STANDARDS FOR THE TURBIDITY OF WATER.

In a paper read before the Illinois Waterworks Association by Francis D. West, chemist in charge of the Torresdale Laboratory, Philadelphia Bureau of Water, the author, in commenting upon the preparation of turbidity standards, regards the principle of correcting a standard determined by weight by the use of a field method as most unsatisfactory. No two laboratories nor any two persons in the same laboratory working independently in the preparation of silica standards, following the procedure outlined, will make standards exactly alike.

A field method is never accurate and the description of what is "An observation in the middle of the day, in the open air, but not in the sunlight, etc.," is a source of many possible interpretations. The amount of light, the size, shape and color of the vessel, the fineness of the material, to say nothing of the personal equation, all influence the results.

What is needed is a definite procedure by which standards can be duplicated from time to time by different chemists without variation.

Such a method has been in use in the laboratories of this bureau since 1901. It involves the use of diatomaceous earth, prepared as follows:

"Wash with water to remove soluble salts; dry and ignite to remove organic matter; treat and warm with dilute hydrochloric acid; wash until free from acid and dry thoroughly. Grind in agate mortar, sifting through 200 mesh sieve and dry in desiccator."

Take a weighed amount of finely ground material, about two grains, suspend in 500 c.c. of distilled water, shaking vigorously from time to time for two or three hours. Suspend for ten hours, decant supernatent liquid. Dry and weigh residue. The difference equals the amount in suspension. Dilute to standard and use as stock.

I have found that standards made in this way from different stocks do not differ perceptibly. All material that remains suspended for ten hours appears to be of the same degree of fineness.

We add a small amount of a saturated solution of mercuric chloride and make standards as follows: Use quart bottles of a high grade of white glass free from air bubbles. The standards are 0, 0.5, 1, 2, 3, 4, 5, 7, 9, 11, 14, 17, 20, 23, 26 parts per million silica. For readings above 26, we use a special nessler jar with a ground glass stopper. We seal these standards. The 100 c.c. standards are 26, 32, 38, 44, 50, 65, 80, 95, 120, 150, 180. For turbidities above 180, dilutions are made with clear water.

During 1913, we made over 24,000 tests with these standards. We have standards made in 1907 still in use. These have been checked from time to time and have not been found to change. We would not recommend using standards over six months without checking.

This method, while it is ideal for the preparation of standards which can always be duplicated, involves considerable labor in the preparation of the diatomaceous earth. The introduction of Fuller's earth seems to be a step in the right direction. I believe this was first brought out by Dr. E. C. Levy, of Richmond, Va., in a paper before the Laboratory Section of the American Public Health Association, although in the report for 1912, he is not given credit for it. The idea, of course, is to do away with the tedious grinding and to obtain a standard which resembles more closely the turbidity of water caused by clay.

Working, then, with two objects in view, of having a definite weight and a definite degree of fineness (obtained by suspension for a definite period) we have experimented with Fuller's earth and have prepared standards which check exactly with our standards made with diatomaceous earth. Our method follows:

If a 200 mesh sieve is not obtainable take about 20 grams of Fuller's earth; if a sieve can be obtained, take about 5 grams of the sifted material (weighing is not necessary). Place in a gallon bottle and add about a quart of distilled water, shake thoroughly, as above, and suspend for ten hours. Decant and determine the weight of the material remaining in suspension by filtering 100-200 c.c. through a weighed Gooch crucible. Dry and weigh.

It will probably be necessary to coagulate the material by the use of a known weight of hydrate of alumina or a solution of alum. In this latter case, the water should be alkaline to precipitate the alum.

The total weight will be the weight of the material in solution plus the weight of the hydrate of alumina.

We know then the degree of fineness as we have suspended for a definite period and we have a known weight. From this suspension we can make our stock for use in preparing our standards.

I do not know just how long the standards will keep, as the period elapsing since their preparation is relatively short compared with our other standards, but in any case it is a simple matter to prepare new ones.

PROGRESS ON HARLEM RIVER TUNNEL.

The sinking of the fifth and last section of the tunnel under the Harlem River, New York City, which is to be a part of the Lexington Avenue subway, has been completed. The tunnel is being built by submerging massive sections of steel tubes which, when connected in position, will be surrounded by concrete and form the bore of the completed tunnel. The procedure is similar to that followed in building the Michigan Central tunnel under the Detroit River at Detroit. The final section, now placed in position, is 250 ft. long. The other four sections are 220 ft. long. The sections are constructed on dry land, and the whole structure is floated into the river by its own bouyancy. Water is then let into the tubes, which are gradually sunk into place, two large floats being used to support the tubes as they are being lowered.

ENGINEERS' LIBRARY

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer.

CONTENTS.

BOOK REVIEWS.

Modern Tunneling, With Special Reference to Mine and Water Supply Tunnels. By David W. Brunton and John A. Davis. Published by John Wiley & Sons, New York; Canadian selling agents, Renouf Publishing Co., Montreal. First edition, 1914. 450 pp.; 80 illustrations; 6 x 9 ins.; cloth. Price, $3.50 net.

This book will be found of exceeding value by those who have been on the lookout for practical information concerning tunneling methods, particularly in the United States. It is confined chiefly to problems of tunneling for drainage, transportation or development, but it also includes those for water power, irrigation or domestic purposes, in which the essential features are very like those of mine tunnels. It should be stated that the book pertains almost entirely to excavation in solid rock and does not refer to soft ground, subaqueous or railroad tunneling.

Following the introduction are chapters on history of tunneling; modern mining and water tunnels; choice of power for tunnel work; air compressors; ventilation; surface equipment; rock-drilling machines; haulage; incidental underground equipment; drilling methods; blasting; methods of mucking; timbering; safety; cost of tunnel work; bibliography. The authors devote little space to the history of tunneling or to old-time methods. They enter at once upon the work of presenting up-to-date information, such as is desired by tunnel engineers who generally feel that up-to-date methods and equipment that are proving safe, efficient and economical are not as widely known as they should be.

Of great interest are the chapters devoted to a discussion of the various types of machinery, plant methods, etc. The advantages and disadvantages of many different varieties of equipment are voiced; tables are presented and the whole treated in such an exhaustive and complete manner as to leave little to be desired on the part of the reader. A chapter on "safety" supplies a very needful part of a book on this subject. The authors have treated it in a practical way that should meet with approval. The chapter on cost of tunnel work gives some excellent data covering the more important tunnels of the United States. This data has already appeared in *The Canadian Engineer* (issues of Sept. 24, Oct. 1, and Oct. 8, 1914). It had been previously collected by the authors for the U.S. Bureau of Mines. (It is in justice to the Bureau to state that the material in the book under discussion is very considerably the same matter as had already appeared in Bulletin No. 57 of the U.S. Bureau of Mines, under the same title, written, of course, by the same engineers.) The bibliography occupies 60 pages, although it has been "selected," as stated by the authors.

The Science and Practice of Management. By A. Hamilton Church. Published by the Engineering Magazine Co., New York. First edition, 1914. 535 pp.; illustrated; 5 x 7 in.; cloth. Price, $2.00.

For one who is searching for a scientific treatment of the fundamental principles and elements underlying scientific management, this volume will be found to go a long way toward analyzing and classifying the existing forms with which they are more or less familiar. The author has endeavored, according to his introductory notes, to ascertain the fundamental facts of production, not from the viewpoint of cost but from the viewpoint of management. One is accordingly impressed with his success in formulating such fundamental facts and regulative principles as may be hereafter developed into a true science of management.

The first part of the volume has to do with the science of management and Part II. with practical organization of the organic function. There are five appendices dealing with the labor question; the expense burden in relation to piecework and premium; the same in relation to bonus; the planning department; some axioms of administrations.

The reader will find the author's classification one by which the information on the subject of management may be scientifically analyzed, properly grouped and, as a result, made more useful.

Strength of Materials. By H. E. Murdock, M.E., C.E. Published by John Wiley & Sons., Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. Second edition, 1914. 352 pp; numerous illustrations; 5 x 7 in.; cloth. Price, $2.00 net.

The first edition of this book was reviewed in *The Canadian Engineer* for Nov. 30, 1911. It is essentially a book for engineering students and has been written with the aim of making intelligible the fundamental principles of the strength of materials without the aid of the calculus. The book is replete with illustrated examples and problems. The subject is proceeded with in the following way: Materials of construction; direct stresses and applications of them; riveted joints; beams, external flexural forces and internal flexural stresses; stresses in such structures as chimneys, dams, walls and piers; graphic integration; deflection of beams; elastic curve; same determined by the algebraic method; secondary stresses; columns and struts; torsion; repeated stresses resilience, hysteresis impact; reinforced concrete beams;

reinforced concrete columns; centroids and moments of inertia of areas, (the latter as an appendix). The book concludes with numerous tables usually found in works on this subject.

Hydraulics. By Louis A. Martin, Jr., Professor of Mechanics, Stevens Institute of Technology. Published by John Wiley & Sons, Inc., New York City; Canadian selling agents, Renouf Publishing Co., Montreal, P.Q. First edition, 1914. 223+12 pages; 114 illustrations; size, 5 x 7½ in.; cloth. Price, $1.50 net.

This work appears as Volume 5, of a set of books by the same author, devoted to mechanics. The previous volumes cover statics; kinematics and kinetics; mechanics of materials; applied statics. In his preface the author states that he has sought to produce a text book which will encourage the student to think and not to memorize, to do and not simply to accept something already done for him. The fundamental principles underlying hydraulics are systematically developed and arranged, with special attention to those underlying the theory and design of impulse wheels and turbines.

The first part of the book is devoted to liquids at rest, and takes up the pressure and the force exerted by a liquid, applications, and floating bodies. Liquids in motion are dealt with in the remaining nine chapters of the book, the work being arranged as follows: The free surface of liquids moving with acceleration; the flow of liquids; flow through orifices, weirs and pipes; force exerted by moving liquids; axial-flow and radial-flow impulse water wheels; turbines.

A feature to be admired in the work is the care that has been given to the selection of exercises and examples. There is an abundance of material in this section of the book to make it of absorbing interest to the student.

Concrete Roads and Pavements. By E. S. Hanson. Published by the Cement Era Publishing Co., Chicago. Revised edition, 1914. 338 pp.; 5 x 7½ in.; illustrated; bound in cloth. Price, $1.50. The first edition of this book was reviewed in *The Canadian Engineer* for August 28, 1914.

The present volume shows one-third increase in size by the addition of seven chapters. The author has made many revisions in the older portion of the work, bringing it up-to-date in every detail. The introduction of new subjects, such as how to promote the construction of concrete roads; the economic methods of handling materials; experimental work, etc., give the book a tone of usefulness that will enhance its value considerably to the road engineer. Other subjects which were treated only briefly in the first edition of the book have been expanded into full chapters. Some new matter has been added to Chapter I., showing the advantages of concrete as a road material, and after this is a chapter discussing the various types of concrete roadways. Following this, the various steps in the construction of concrete roads and pavements are taken up in separate chapters, these covering the preparation of the sub-grade, the selection of materials, economic methods of handling materials, mixing and placing the concrete, finishing and curing. The chapter on joints has been brought fully down to date, while the chapters descriptive of work done in various localities have been considerably augmented by the addition of descriptions of recent work accomplished.

To the appendices appearing in the first edition there has been added the specifications of the American Concrete Institute. The list of specifications now includes, in addition to the above, specifications for Wayne County, Mason City, Illinois Highway Commission, Blome Granitoid and Granocrete pavements, Bitustone, Dolarway, Hassamite, Vibrolithic, bridges and culverts, sidewalks, curb and gutter.

The expansion of the book is well worth the notice, even of those already familiar with the first edition.

The Calculus. By John Graham, B.A., B.E. Published by E. and F. N. Spon, Limited, 57 Haymarket, S.W. Fourth edition. Cloth; 5 x 7 in.; 355 pages; 116 illustrations. Price, $1.25 net.

This volume is an elementary treatise on the calculus for engineering students. It covers the differential and integral calculus and the solution of differential equations. The book is very complete with numerous examples and problems worked out.

Hydraulics. By W. M. Wallace, Wh.Sc. Published by the Technical Publishing Company, Limited, 55 Chancery Lane, London, W.C. Cloth; 5 x 7 ins.; 276 pages. Price, $1.00 net.

This little volume is intended to supply the wants of the practical engineer and the student. In the first two chapters, hydrostatic principles and hydraulic machines are dealt with; the flow of water in pipes and through orifices is covered in Chapters III. and IV. Chapter V. deals with the impact of water on surfaces; Chapter VI. with centrifugal head, while Chapters VII., VIII. and IX. deal with the water turbine, the centrifugal pump and the turbine pump. The titles of the other chapters are: Chapter X., Loss of Energy Due to Shock; Chapter XI., Pumps; Chapter XII., Measuring the Flow of Water; Chapter XIII., Channel Fow; Chapter XIV., Fluid Friction; Chapter XV., Vibration and Rolling; Chapter XVI., Hydraulic Problems. This is a valuable little reference book for the engineer in practice, and a good text book for the student.

Hand Book of Construction Plant: Its Cost and Efficiency. By Richard T. Dana, M.Am.Soc.C.E. Published by Myron C. Clark Publishing Company, Chicago. 702 pp.; numerous illustrations; size, 4½ x 7 ins.; limp leather. First edition. Price, $5.00 net.

The object of this book is to furnish contractors with information in ready reference form concerning the cost, capacity, operating expenses and adaptability of equipment most generally required. Much well-arranged information is given that is invaluable to an inexperienced contractor, and that would undoubtedly be of considerable interest even to a man of broad experience. The book is especially useful to a contractor who has kept but little cost data or who is not in close touch with the costs, merits and sources of supply of equipment.

The usefulness of the volume to Canadian contractors, however, is hampered by the fact that only United States, and no English or Canadian equipment, is discussed, and the lists given of prices, makes and kinds cover only United States firms. While a vast amount of excellent equipment is bought in the United States every year by Canadian contractors, it is obvious that no Canadian contractor could afford to make any purchase without giving due consideration to the competitive merits and prices of Canadian and English goods. The book is not simply compiled from the Canadian standpoint, but will no doubt meet with a very good sale in the field which it is intended to cover.

PUBLICATIONS RECEIVED.

Philadelphia Public Works.—Annual Report (1913) of the Director, Department of Public Works, city of Philadelphia.

Timber and Soil Conditions of Southern Manitoba.—By L. G. Tilt, B.Sc.F., Forestry Branch, Department of the Interior, Canada. 36 pp.; illustrated.

Kewagama Lake Map-Area, Quebec.—By M. E. Wilson, Memoir 39, Geological Survey, Department of Canada. 140 pp.; numerous plates and illustrations.

Magnetic Occurrences near Calabogie, Renfrew County, Ontario.—By E. Lindeman, Mines Branch, Department of Mines, Ottawa, describing location, history, geology, ore deposits, etc.

Farmer as a Manufacturer.—By A. T. Stuart, B.A., assistant chemist, Department of Agriculture, Experimental Farms. An outline of some basic principles in agricultural chemistry. 16 pp.; 6 x 9 in.

Pollution of Des Plaines River.—Report of the sanitary district of Chicago. 55 pp.; 6 x 9 in.; illustrated. It outlines investigations of conditions along the river in new territory annexed by the city in 1913.

Moose Mountain Iron-Bearing District, Ontario.—By E. Lindeman, Mines Branch, Department of Mines. 32 pp., describing location, general historical and geological features, character of ore and commercial possibilities.

The Archæan Geology of Rainy Lake Restudied.—By A. C. Lawson, Geological Survey, Department of Mines. Published as Memoir 40. 115 pp.; 6 x 9 in.; plates and illustrations. A report upon investigations in Northwestern Ontario in 1911.

Gold Fields of Nova Scotia.—By W. Malcolm, Geological Survey Branch, Department of Mines. 330 pp.; 52 plates, 24 figures and 2 maps. It is a compilation of data, the result of field investigations and studies of Mr. E. R. Faribault.

Resuscitation from Mine Gases.—Technical Paper No. 77, United States Bureau of Mines, report of committee. 36 pp.; illustrated. It outlines manual and mechanical methods of artificial respiration, experiments with commercial devices, etc.

The Humidity of Mine Air, with special reference to coal mines in Illinois. By R. Y. Williams, United States Bureau of Mines (Bulletin 83). It is devoted to a resume of mine humidity investigations, methods of humidification, conclusions and suggestions.

A Study of the Oxidization of Coal.—By H. C. Porter and O. C. Ralston, United States Bureau of Mines. 30 pp.; 6 x 9 in. Rate of oxidization of different coals compared and factors affecting described. Experiments to determine nature of oxidization reactions outlined.

Valuation of Ohio Public Utilities.—Report of a joint committee of the Public Utilities Commission. 42 pp.; 6 x 9 in.; price, 50 cents. It outlines the committee's formulation of principles as applied to "Reproductive cost new, less depreciation," method of valuing public utilities.

Topographical Surveys Branch.—Annual report for 1913 of this Branch, Department of the Interior, Ottawa. 226 pp.; 6 x 9 in.; 17 maps and profiles; numerous illustrations. It contains the report of the Surveyor-General, various schedules, lists and statements, and the reports of surveyors.

Timber Conditions in Alberta.—A report on the timber conditions of Little Smoky River Valley and adjacent territory. By J. A. Doucet, Forestry Branch, Department of the Interior. 52 pp.; illustrated. It outlines general conditions, report on the country by blocks, fire protection, and the proposed forest reserve.

Telephone Systems.—The Ontario Telephone Act and Amendment thereto. Extract from report of Ontario Railway and Municipal Board for 1913. Specifications for construction of telephone systems. Forms of petition, by-laws, etc. 60 pp. Copies on application to the Ontario Railway and Municipal Board, Legislative Buildings, Toronto.

The Double-Curve Motive in Northeastern Algonkian Art.—By Frank G. Speck, Geological Survey, Department of Mines, Ottawa. It contains very interesting information respecting the occurrences of the motive among the tribes south and north of the St. Lawrence and in adjacent areas westward. There are 18 plates and 25 figures of note.

Forests, Waterways and Water-Powers.—Report of the select standing committee, Ontario Legislature. 28 pp.; 6 x 9 in. The committee's report has appended to it: (1) Conservation of natural resources in British Columbia (7 pages); Sir Richard McBride. (2) Work of the Provincial Forestry Department in British Columbia (11 pages); H. R. McMillan.

Irrigation.—Annual report for the year 1913 of the Department of the Interior. 172 pp.; numerous illustrations. It contains reports on the districts of Calgary and Maple Creek; on special inspection; on the South Saskatchewan and St. Mary River diversion projects; stream measurements; Bow River flood discharge and floods in the North Saskatchewan drainage basin.

Thermal Properties of Steam.—By G. A. Goodenough. Bulletin No. 75, Engineering Experiment Station, University of Illinois, Urbana, Ill. 69 pp.; 6 x 9 in.; illustrated. It presents a critical discussion of the experimental investigations, an outline of the thermodynamic relations that must be satisfied, and the development of a general theory of superheated and saturated steam.

Lode Mining in Yukon.—An investigation of quartz deposits in the Klondike Division, by T. A. MacLean, M.E., Mines Branch, Department of Mines, Canada. 222 pp., with 6 maps, 36 sketches and 40 photographs; size, 6 x 9 in. The report deals with the quartz deposits in the mining districts of Duncal Creek, Conrad and Dawson, with a view to describing their gold contents and reporting upon their economic value.

Water Measurement in Open Channels.—A description by C. R. Weidner, C.E., of the diaphragm method for the measurement of water in open channels of uniform cross-section. Issued as Bulletin No. 672 of the Engineering Experiment Station, University of Wisconsin, Madison, Wis.; price, 25 cents. 72 pp.; size, 6 x 9 in.; 6 plates; 30 figures. Describes the apparatus in various European stations, giving results of tests, etc.

Port Directory of the Principal Canadian Ports and Harbors, 1913-14.—Department of Marine and Fisheries, Ottawa. 305 pp.; fully illustrated; 6 x 9 in.; bound in cloth. The volume contains, in addition to the above, data respecting a large number of minor ports, wharves, depth of water, facilities for loading, etc.; also descriptions of types of aids to navigation in Canadian coastal and inland waters, navigable distances of many rivers in the north-west of Canada, and general information for mariners.

The Copper Smelting Industries of Canada.—By A. W. G. Wilson, Ph.D., chief of the Metal Mines Division, Department of Mines, Canada. 184 pp.; 6 x 9 in.; 43 plates, 4 maps and 39 illustrations. The report takes up the various smelters by provinces in Chapter 1. Following it are chapters devoted to the Canadian Copper Co., the Mond Nickel Co., Limited, the Consolidated Mining and Smelting Co. of Canada, Limited, Granby Consolidated Mining, Smelting and Power Co., British Columbia Copper Co., Tyee Copper Co., miscellaneous summaries and statistics of copper production.

CATALOGUES RECEIVED.

The World's Greatest Asphalt Plant.—The Barber Asphalt Paving Co., Philadelphia, issues a 16-page illustrated description of their plant at Maurer, N.J.

Tubular Steel Tripods.—A leaflet describing the Morris folding tubular steel tripod, issued by the Herbert Morris Crane and Hoist Co., Limited, Toronto.

Jeffrey Limestone Pulverizer.—Bulletin No. 132, of the Jeffrey Manufacturing Co., Columbus, Ohio. Describes the swing hammer pulverizer, type "D," with diagrams. 8 pp.

Synchronous Converters.—Bulletin issued by the Canadian General Electric Co., listing the ratings of standard lines of converters for various frequencies, voltages and capacities.

Morris Hand Overhead Travelling Crane.—A 4-page leaflet, issued by the Herbert Morris Crane and Hoist Co., describing a new type designed to run on the lower flange of two parallel I-beams.

Sprague Electric Monorail Cranes.—48 pp.; fully illustrated, describing the function and various types and capacities of these cranes. Issued by the Canadian General Electric Co., Limited, Toronto.

Speed Regulation.—A 4-page leaflet describing a new invention called the Douglas Speed Regulator, of interest to engineers and manufacturers. Issued by J. A. Douglas, 626 McMillan Avenue, Winnipeg, Man.

Westinghouse Turbo-Alternators.—A 40-page profusely illustrated description of various types. It traces the development of the steam turbine, of reaction and impulse turbines, and of variations in modern designs.

Temperature Control Apparatus.—A booklet descriptive of the Grundy System of automatic temperature control. Also information about heating and ventilating by electricity. Issued by A. Schonfield and Co., Glasgow.

Lackawanna Plate Sheet Piling.—Bulletin No. 107, outlining a new section just brought out by the Lackawanna Steel Co., for whom H. A. Drury Co., Limited, Montreal, are Canadian representatives. 4 pp.; illustrated.

Heavy Traffic Centres.—A descriptive publication of the Westinghouse Electric and Manufacturing Co., giving a number of interesting and instructive illustrations showing operating conditions in many large traffic centres.

Electrical Equipment for Oil Wells.—A 24-page bulletin, well illustrated and containing some instructive information on the use of electrical apparatus in the oil fields. Issued by Canadian General Electric Co., Limited, Toronto.

Drawing Tables, etc.—A 48-page catalogue, issued by Economy Drawing Table Co., Toledo, Ohio. Drawing tables, filing cases and specials for engineers, architects, contractors, manufacturers, schools, etc., are described.

Piston Rings.—A small 8-page booklet, published by the Burd High Compression Ring Co., Rockford, Ill. Reprinting an article by H. S. Whiting on "How the Efficiency of a Motor Car is Dependent upon Gas-Tight Ring Joints."

Steam Engines for Direct Connection to Electric Generators.—16 pages, describing the Chandler and Taylor engines, simple, tandem and cross compound. Issued by Canadian Allis-Chalmers, Limited, Toronto, agents for Canada.

Train Operation.—A collection of illustrations, with brief notes, showing some of the advantages of multiple-unit trains for city, suburban and interurban service. 16 pp.; 8½ x 11 in.; illustrated. Issued by the Westinghouse Electric and Manufacturing Co., East Pittsburgh.

Despatchers' Selective Signalling System.—A leaflet from the general railway signal company, Rochester, N.Y., describing a new system by means of which the despatcher can control train-order signals and take-siding signals located at various stations, and determine the indication displayed by each.

Horsfall Destructors.—A 50-page catalogue, issued by the New Destructor Co., Limited, Pershore, England, describing the features of this type of destructor and a number of the plants now in operation. Other equipment for destructor plants, such as crushing and screening plant, tin-baling machines, etc.

Marshall Traction Engines and Road Rollers.—A fully illustrated 44-page catalogue, issued by Marshall, Sons and Co., Limited, Gainsborough, England (Canadian office, Saskatoon, Sask.) It describes different sizes of traction engines and road locomotives, single and compound; road rollers, scarifiers, trailer wagons, etc.

MILITARY PROMOTION FOR C. H. MITCHELL, C.E.

Word has been received from the military authorities at Ottawa of the appointment of Major Charles H. Mitchell, of Toronto, to the important position of General Staff Officer on the Headquarters Staff of the First Contingent, and also of his promotion to the rank of Lieut.-Colonel. This appointment is one of the highest given to any militia officer in Canada. Lieut.-Colonel Mitchell is deserving of this distinction, and military men in Toronto assert that he is perhaps the best qualified Canadian officer for the position.

Lieut.-Colonel Mitchell is perhaps better known generally throughout the Dominion as "C. H. Mitchell, C.E.," of the firm of C. H. and P. H. Mitchell, Consulting Engineers, Toronto. His experience in engineering has been wide, but his activities have been chiefly in hydro-electric and hydraulic work. For the past four years he has been consulting engineer for the Dominion Government on water-power matters, particularly in Western Canada.

Lieut.-Colonel Mitchell is a member of the Board of Governors of the University of Toronto, from which university he graduated in 1892. He has also taken an active part in the advancement and improvement of the city of Toronto, and for many years has been on the Executive of the Toronto Civic Guild, of which organization he is now the President.

ST. JOHN VALLEY RAILWAY, N.B.

The Canadian Pacific and the Intercolonial have patched up their differences relative to facilities for entering the St. John Valley Railway into Fredericton. The railway will enter from the south by double-tracking the C.P.R. from Victoria Mills to the Intercolonial "Y"; thence by their own tracks. The Quebec and St. John Construction Co. may do their own double-tracking on this work or may sub-let it. As soon as this connection has been completed operation of the Valley Railway will be commenced between Frederiction and Gagetown.

It is stated in a recent communication from Fairville, N.S., that the installation of a 12-inch water main along the Sand Cove Road has been completed as far as the Fairville pl teau; that concrete sidewalk has been completed for some distance out the Manawagonish Road; and that progress on the new Government bridge over the Reversible Falls is favorable. Of the bridge construction, the granite piers which are being erected on the east side have been completed. The trestle which was built from the C.P.R. track and crosses the road overhead has been finished and the crane for hoisting the steel into position has been placed on the cliff overlooking the falls, the steel construction now being in progress.

Coast to Coast

London, Ont.—The proposed new municipal sewage disposal plant for the east end of the city has been under consideration last week and a number of suitable sites inspected.

Hamilton, Ont.—A start was made last week on the concrete foundation of the first building of the new plant of the Proctor-Gamble Co. and excavation is progressing for the other buildings. About 150 men are at work and the contractors are rushing things before cold weather sets in.

Amherst, N.S.—The Canada Car and Foundry Co. have a large number of cars of various types under construction in the passenger department. For the past few months from 350 to 500 men have been employed, and it is probable that this number will be increased from time to time during the winter.

Hamilton, Ont.—Hamilton authorities, thinking the expenditure of $328,000 for a bridge, 1,600 ft. in length, in connection with the Toronto-Hamilton highway, to be too great, have asked the Hamilton Bridge Works for plans and estimates of a bridge about 1,000 ft. in length. The purpose of this bridge is to do away completely with the Valley Inn Hill.

Moose Jaw, Sask.—Mr. Geo. D. Mackie, engineer-commissioner, owing to the shortage of the Caron water supply, due to exceptionally dry weather having reduced the flow from the infiltration galleries, recommends the use of Snowdy Springs water, which will require the use of a filter to be installed at South Hill. If the scheme is carried out it will provide the city with an additional supply of 200,000 gallons.

Kirkland Lake, Ont.—During the past week two new plants have been started in the Kirkland Lake section of Northern Ontario. At the Lake Shore Gold Mines a 3-drill air-compressor has just been installed and operations have commenced on a shaft, already sunk by hand-drill to a depth of 40 ft. A station will be established and drifting started at the 100-ft. level. The other plant is that of the Kirkland Lake Gold Fields, and will operate five drills. It is run by two boilers of 110 h.p. Sinking has been started and will be carried to 100 ft. on the continuation of the Teck-Hughes main vein, picked up some months ago on the McKane property (worked by the company) under heavy overburden.

Summerside, P.E.I.—In addition to completing that portion of the 1913 programme of steel and concrete bridge construction which had to be left unfinished, the provincial department of public works has built a number of other bridges this year. Of last year's work the most important is the big bridge over the Cardigan River. This structure comprises two steel spans of 280 feet in length, clear of the approaches. The bridge has a concrete roadway and a 4-foot sidewalk, the width of the bridgeway being about 16 feet. This bridge was commenced last fall, and at present the entire superstructure, including the concrete roadway, has been completed; while the construction of the approaches is now under way. It is expected that it will be opened for traffic in the course of another month. A concrete culvert bridge was also erected near Cardigan this year. At Wigginton's a 35-foot steel bridge has been erected in the place of the previously existing wooden one. Fortune bridge of two 120-foot steel spans has been completed, this permanent structure also replacing a wooden bridge. A Mink River, a 100-foot steel span bridge has been erected; near Crapaud another 35-foot steel bridge; while one with 25-foot steel spans is in course of erection at Ahearn's, Tignish.

PERSONAL.

A. T. ENLOW, sales manager of the Pedlar People, Limited, Oshawa, Ont., has resigned.

A. I. DAVIS, B.A.Sc., has been appointed mining engineer for the United States Gypsum Co. at Fort Dodge, Iowa. Mr. Davis is a graduate in mining of the University of Toronto.

W. N. ASHPLANT, city engineer of London, Ont., has applied for service in the second Canadian contingent. Mr. Ashplant is a South African veteran and a lieutenant in the 17th Fusiliers, London.

GEO. W. COBURN, district engineer for the Canadian Pacific Railway Co. at Souris, Man., has been transferred to Brandon, Man., where he will serve in the same capacity. Mr. Coburn has been with the C.P.R. since 1896.

Prof. GEO. A. GUESS, of the Department of Metallurgy, University of Toronto, is at present in Anyox, B.C., where he has been engaged for a short time in a consulting capacity by the Granby Co. in connection with their new smelter.

E. MAERKER, A.Sc., of Toronto, has accepted a position with the Winnipeg River Power Co., at Winnipeg, and assumes his duties next week. Mr. Maerker was previously designing engineer with the Toronto Power Co. on high-tension transmission work.

Hon. T. CHASE CASGRAIN, K.C., chairman of the Canadian section of the International Joint Commission, has been appointed Postmaster-General for Canada. His successor on the Commission will likely be appointed forthwith, as the Commission meets in Detroit on November 10th.

F. N. SMITH, resident engineer of construction, Canadian Northern Pacific Railway, Henningsville, B.C., and D. R. WEBER, assistant superintendent, Grant Smith and Co. and McDonnell, Limited, Revelstoke, B.C., have recently attained associate membership in the American Society of Civil Engineers.

OBITUARY.

Hon. COLIN H. CAMPBELL, formerly Minister of Public Works for the Province of Manitoba, died at his home in Winnipeg on October 24th after an illness of about 2 years.

TORONTO BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

On Wednesday, Oct. 28th, the Toronto Branch of the Canadian Society of Civil Engineers met at the Engineers' Club to hear an address on "Naval Architecture," delivered by Prof. J. R. Cockburn, of the University of Toronto. The meeting was largely attended. Mr. Cockburn also illustrated by a number of slides the various types of vessels employed by the British Admiralty.

On Saturday, Oct. 31st, members of the Branch, accompanied by members of the University of Toronto Engineering Society, will take a trip over the new Welland Ship Canal work. Sections 1, 2 and 3 present many important and instructive engineering features that will be of special interest to the visitors, who will be shown over the work by Mr. J. L. Weller, chief engineer of the canal, and his engineering staff.

In order to see all the work under construction open street cars will be hauled over the track on the west bank of the canal. Arrangements also provide for inspecting the harbor work at Port Weller. Luncheon will be served in one of the construction camps. In the evening the ladies of St. Catharines will provide a dinner, the proceeds of which will go to the Patriotic Fund.

The library committee of the Branch has announced the addition since the last annual meeting of a considerable number of valuable series of transactions, proceedings, journals and reports as well as some 80 engineering treatises and text books. These new books comprise the most recent works on bridge engineering, cement and concrete, ceramics, chemical engineering, electrical engineering, foundations, heating and ventilating, highway engineering, hydraulics, mechanical engineering, metallurgy, railway engineering, sanitary engineering, steam engineering, structural engineering and water supplies. The usefulness of the periodic literature in the library has also been considerably increased. The committee consists of Messrs. W. A. Hare, A. L. Mudge and Prof. C. R. Young, chairman.

HIGHWAY STUDY AT COLUMBIA.

The non-resident lecturers in the graduate course in Highway Engineering at Columbia University appointed for the 1914-1915 session are as follows: John A. Bensel, New York State Engineer; Edward D. Boyer, Cement and Concrete Expert, the Atlas Portland Cement Company; Sumner R. Church, Manager, Research Department, Barrett Manufacturing Company; William H. Connell, Chief, Bureau of Highways and Street Cleaning, Philadelphia; W. W. Crosby, Chief Engineer, Maryland Geological and Economic Survey, and Consulting Engineer; Charles Henry Davis, President, National Highways Association; Arthur W. Dean, Chief Engineer, Massachusetts Highway Commission; John H. Delaney, Commissioner, New York State Department of Efficiency and Economy; A. W. Dow, Chemical and Consulting Paving Engineer; H. W. Durham, Chief Engineer of Highways, Borough of Manhattan, New York; C. N. Forrest, Chief Chemist, Barber Asphalt Paving Company; Walter H. Fulweiler, Chief Chemist, United Gas Improvement Company; D. L. Hough, President, the United Engineering and Contracting Company; William A. Howell, Engineer of Streets and Highways, Newark; Arthur N. Johnson, Highway Engineer, Bureau of Municipal Research, New York; Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, New York; Philip P. Sharples, Chief Chemist, Barrett Manufacturing Company; Francis P. Smith, Chemical and Consulting Paving Engineer; Albert Sommer, Consulting Chemist; George W. Tillson, Consulting Engineer to the President of the Borough of Brooklyn, New York; and George Warren, President, Warren Brothers Company.

G.T.R. MASTER MECHANICS.

The following Grand Trunk staff changes have been announced: J. Markey is appointed master mechanic of Ontario lines with headquarters at Toronto, and J. R. Donnelley is named as assistant master mechanic of Ontario lines with headquarters at Allandale, the title of master mechanic of the northern division being abolished. T. McHattie is appointed master mechanic of eastern lines with headquarters at Montreal, and the title of master mechanic of the Ottawa division is abolished. W. H. Sample is appointed master mechanic of western lines with headquarters in Battle Creek, Mich.

CANADIAN ENGINEERS AT THE FRONT.

In addition to the list of graduates and undergraduates of the University of Toronto who are now in England with the first Canadian expeditionary force there should be added the names of Messrs. P. J. McCuaig, '09; H. N. Klotz, '09, and W. J. Baird, '10.

We announced Mr. H. F. H. Hertzberg, chief engineer of the Canadian Bridge Co., Walkerville, as a member of the contingent. As many of our readers are aware, this should have read, "Mr. H. F. H. Hertzberg, engineer of the Trussed Concrete Steel Co. of Canada, Walkerville, Ont."

THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

On Thursday, Oct. 22nd, a largely attended meeting of the Canadian Society of Civil Engineers was held in the Society's headquarters, 176 Mansfield Street, Montreal, Walter J. Francis, C.E., presiding. A paper, illustrated by slides, and entitled "The System of Unit Construction in the Concrete Power House at Cedars, P.Q.", was read by Mr. J. E. Conzelman, chief engineer of the Unit Construction Co., Montreal. The speaker dealt in detail with the use of reinforced concrete in the construction of large industrial and similar buildings. The application of the "unit construction" to the power house of the Cedars Rapids Manufacturing and Power Co., as described by Mr. Conzelman, aroused a good deal of discussion and was of great interest.

Another paper, entitled "Mushroom Construction," by Mr. C. A. P. Turner, had to be postponed until a later meeting as the discussion following the first paper occupied the greater part of the meeting.

CHANGE OF ADDRESS.

The Ottawa Branch of the Canadian Society of Civil Engineers has changed the address of its headquarters from 177 Sparks Street to 128 Queen Street, Ottawa.

COMING MEETINGS.

NORTHWESTERN ROAD CONGRESS.—Annual Convention, to be held at Milwaukee, Wis., October 28th to 31st. Secretary, J. P. Keenan, Milwaukee.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Charles Carroll Brown, Secretary, Indianapolis, Ind. Meets at Somerset Hotel, Boston, Mass., October 21st, 22nd and 23rd.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

WASHINGTON STATE GOOD ROADS ASSOCIATION.—Convention to be held at Spokane, Wash., November 18th, 19th, and 20th. Secretary, M. D. Lechey, Alaska Building, Seattle, Wash.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

EIGHTH CHICAGO CEMENT SHOW.—To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.

Volume 27. Toronto, November 5, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

Fig. 1.—The Harbor Under Construction at Port Weller.

WELLAND SHIP CANAL CONSTRUCTION

NOTES ON THE SEASON'S ACTIVITIES IN THE CONSTRUCTION OF CANADA'S $50,000,000 WATERWAY BETWEEN LAKES ERIE AND ONTARIO, UNDER THE DIRECTION OF THE DEPARTMENT OF RAILWAYS AND CANALS, OTTAWA.

THE present season has been one of remarkable activity along the line of the proposed New Welland Ship Canal. The northern portion of the route has been converted into a scene of constructional development embodying works whose proportions and involved methods of construction are on a scale with which few of our Canadian enterprises are comparable, and certainly far beyond anything of a similar nature ever attempted in this country.

For general information respecting the new route, and essential features of design, the reader is referred to an article which appeared in *The Canadian Engineer* for August 21st, 1913. Briefly, it is to replace the present Welland Canal whose length of 26¾ miles from Port Colborne on Lake Erie to Port Dalhousie on Lake Ontario, provides, through 25 locks, the only existing means of water transportation in this section of the Great Lakes' route. The old canal, with locks 45 feet in width, afforded some 14 ft. of water over the sills. The new canal will be 25 miles in length, from lake to lake, overcoming a difference of level of 325½ feet. There will be seven locks, each of 42½ ft. lift, 80 ft. width, and of sufficient length to accommodate a vessel 800 ft. long. The present construction is to provide a depth of 25 ft. over the sills; this to be ultimately deepened to 30 ft., according to the design.

Fig. 2.—Drag Line Excavator in Lock No. 1, Port Weller.

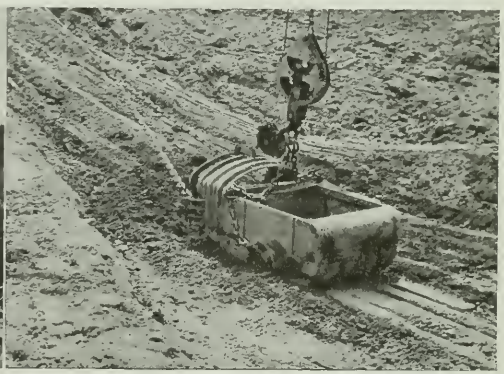

Fig. 3.—Drag Line Bucket at Work on Site of Lock No. 1.

The work has been divided into nine general sections and up to the present contracts have been let for Sections 1, 2, 3, 5, and a portion of Section 4, called 4A.

Section 1.—The contract for Section 1 was let on August 1st, 1913, to The Dominion Dredging Company, Limited, Ottawa, at about $3,500,000. It extends from deep water about 1½ miles from the Lake Ontario shore line to Sta. 150, about 1½ miles inland. The contract includes the construction of Lock 1, the lower end of which is about 2,500 ft. from the shore line. There is a lock wall about 800 ft. in length and an entrance wall also 800 ft. long. The inland part of this section entails a large amount of dry excavation. The contract also includes sub-structures for two bridges. One of these will be situated over the head of Lock 1 and will be for the electric line to Niagara, of the Niagara, St. Catharines and Toronto Railway. This will comprise a bascule lift bridge over the Canal proper with 95 ft. clear span, and a reinforced concrete approach of six spans over the regulation weir on the east side. The two outer spans will be 41½ ft. and the four central spans 40 ft. in length. The contract calls for the complete construction of this approach.

The other bridge, No. 2, will also be a bascule lift highway bridge, but of 200 ft. span. It will be situated about a mile south of bridge No. 1, and will lie between the second and third concessions of the Township of Grantham.

A considerable part of The Dominion Dredging Co.'s contract consists of the construction of a harbor at Port Weller. This harbor is to be formed by two earth dykes about 500 ft. in width and extending, as stated, 1½ miles from shore line. These dykes each carry a temporary trestle used in their formation. This trestle carries the tracks of a railway to be described later. Here all the surplus material from Sections 1 and 2 and the lower end of Section 3 is being dumped. At present the trestle on the west side extends over half way out and that on the east side is almost as far advanced.

It is expected that the side embankments of the harbor will eventually be three or four hundred feet in width at the top at the narrowest point, and considerably wider toward the shore. The material dumped into these embankments washes away to a very small extent under normal conditions, and even during storms no great quantity has so far been taken out. When the earth filling is completed rock will be brought from Section 3 to roughly rip-rap the outer slopes.

The work in the lake includes dredging a 25-foot channel from deep water to the shore line, the material being cemented gravel and hard-pan overlying shale rock. Some of the latter will also be removed.

The harbor work includes the building of 55 cribs, each weighing about 2,000 tons, to be placed at the entrance piers and at the east docking and gate yard slip, near the shore line. Each is 110 ft. in length, 38 ft. wide and 34 ft. deep and contains 18 compartments, each 12 x 18 ft. The exterior walls are 18 in. wide at the bottom, tapering to 12 in. at the top. The base and top widths of the interior walls are 14 and 10 in. respectively. There is an offset at the bottom of each compartment providing a seating for a movable timber bottom. When the cribs are floated to position they are sunk by the removal, by chain operation, of these bottoms. When sunk they will be filled with earth. One of the cribs has already been constructed and floated out into the lake and temporarily rests on bottom pending the dredging of a deeper channel and the preparation of the site. The bottoms of the compartments of the crib are, as stated, removable, and will be used over and over in the construction and placing of the different cribs. When sunk, the top of the cribs will reach water level. They will extend for a distance of 700 feet on either side of the harbor entrance. Upon such cribs also will be placed the concrete superstructure forming the lines of docking at the shore end of the harbor.

The entrance wall to Lock No. 1 involves some interesting construction. The steel frame work, 41½ ft. in height, and a large part of the steel reinforcing has already been placed and considerable concreting has been done. The entrance wall extends from near the lake to the foot of the lock and is of reinforced concrete, buttress type. In the use of the structural steel frames, one in each counterfort, a departure from ordinary design has been made. These frames are for the purpose of supporting the reinforcing rods, many of which pass through holes punched through the framework, and also for supporting the concreting forms. The illustrations of this

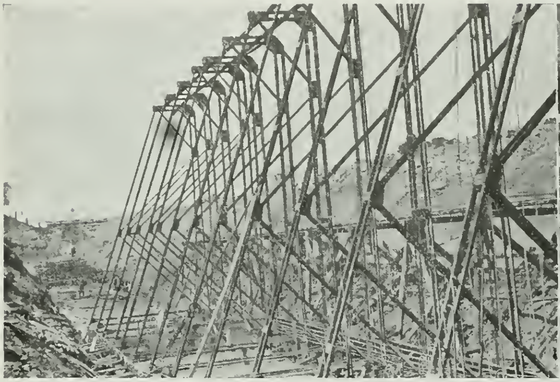

Fig. 4.—End Section of Steel Frame for West Entrance Wall at Port Weller, Before Placing Reinforcing Steel.

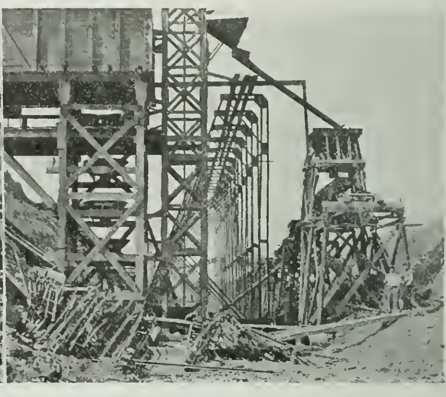

Fig. 5.—Part of the Concreting Plant at the South End of the Retaining Wall.

wall show some interesting reinforcing work. The wall has a rock foundation. The reinforced concrete crib docking, mentioned above, will extend from its outer extremity into the harbor.

At work in the harbor is a sounding scow about 40 feet square, and provided with 4 large spuds or anchors. This scow was built for the general purposes of the survey staff in connection with the harbor work, but principally for ascertaining the elevation of the surface of the rock beneath the overlying material. As it was liable to be caught out in rough weather before the piers were extended as far as they are into the lake, and as sometimes a perfectly steady platform is required, the scow is arranged with a heavy engine on each spud, by means of which the scow is enabled to hoist itself completely out of the water and above the reach of wave action, which will thus have only the four spuds to strike against. When it is required to move the machine the scow is lowered into the water and the spuds lifted up clear of the bottom by the same machinery.

A reinforced concrete scow, built in 1910, is also engaged on the work.

Up to the end of September the work done on Section 1 of the Canal included about 300,000 cubic yards of dredging from the harbor and about 1,000,000 cubic yards of dry excavation from the lock division. This material has all been used in the embankment construction.

Section 2.—This was let by contract on December 31st, 1913, to Baldry, Yerburgh & Hutchinson, an English firm with an office in St. Catharines. It extends from Sta. 150 to Sta. 380, approximately 4⅓ miles, and includes the construction of Locks 2 and 3, with necessary entrance walls, regulating and supply weirs. Substructures for three bridges will be required in addition to road diversions, etc. Bridge No. 3 will be an 80-ft. bascule bridge to be used for highway purposes and will be situated over the head of Lock 2. The contract requires the construction of a reinforced concrete approach of six spans, each 40 ft. in length and 21½ ft. wide.

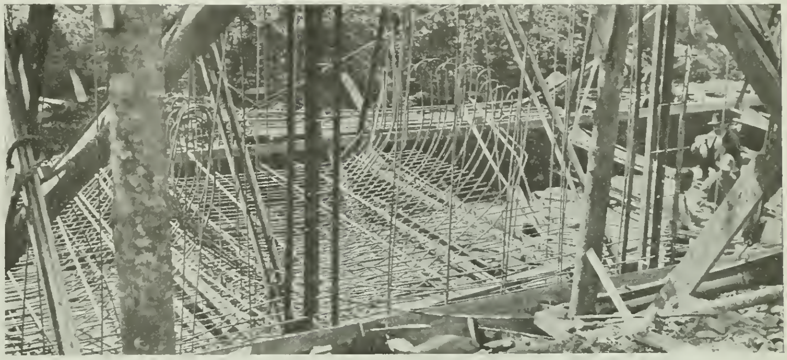

Fig. 6.—Reinforcing Steel at the Base of One of the Counterforts—West Side Entrance Wall, Port Weller.

Bridge No. 4, to be also of bascule lift type, will have a 200-ft. span with earth approaches. It will be over the Queenston Road and about midway between Locks 2 and 3. The location of bridge No. 5 is on the St. David's-Merritton Road, near the boundary line of Sections 2 and 3 of the canal. It will also be a bascule lift bridge with a span of 200 ft.

In Section 2 there will be a crossing of the present and new canals. The water in both is to be at the same level thereby affording vessels an alternative passage to or from Lake Ontario by way of Port Dalhousie. This will probably be taken advantage of largely by smaller craft.

Fig. 7.—Grader and Mule Outfit Working on a Watertight Embankment, Section 2.

During the season the embankments for a pondage of 200 acres required for Lock No. 2 have been in progress, east of the canal bank. About half a mile of it is completed. Six elevating graders have been employed on the work. A dam is also being built to the east of Lock 3, to form an equalizing basin. Lock 1 will also have a pond. These basins are necessary in order to prevent fluctuations in the levels when a lock is filled or emptied, as the filling of a lock would lower the water in a 70-acre pond one foot. It is therefore advisable to have these ponds as much over 70 acres as possible.

At the site of Lock No. 2, the excavation for a heavy breast wall is in progress. A cavity about 175 ft. long and 25 ft. wide has been made and enclosed in sheet piling 45 ft. in length, driven to refusal and supported by wooden bracing. Excavation will be carried to a depth of 60 ft. to solid rock, whereupon the pit will be filled with concrete, thus forming the breast wall for Lock No. 2.

Fig. 8.—Rock-cut on G.T.R. Relocation, 3rd Curve. Thorold (Section 3).

This method of construction was adopted in order to conserve the ground above the breast wall in its natural state, as, had the lock pit been excavated in the usual manner, it would have been open for a couple of years, during which time a slope probably flatter than 1 to 1 would have formed above the breast wall, as well as along the sides of the pit. The present method will leave the material above the breast wall intact.

The contractors had completed on September 30th, 1914, a total of 1,500,000 cubic yards of dry excavation in Section 2. All this material, with the exception of that required for grading the construction railway, has been transported to the harbor site and used in the construction of the dykes. The section involves the excavation of about 6,000,000 cu. yds. of earth. This part of the work has proceeded very rapidly by means of heavy steam shovels, drag-line excavators and several mule outfits operated in connection with grading machines. The embankments are being built by mule teams hauling wagons from the grading machines to the different banks, where it is placed in layers and compacted after being watered.

Section 3.—The contract for Section 3 was let on October 4th, 1913, to O'Brien & Doheny, Montreal, and Quinlan & Robertson, Toronto, in combination, the price being approximately $9,500,000. It extends from Sta. 380 to Sta. 490 and includes the twin Locks Nos. 4, 5 and 6 in flight, single Lock No. 7, and guard gates. A part of the contract is the diversion of the Welland Division (to Port Colborne) of the Grand Trunk Railway. At present this line extends along the right-of-way of the canal. The relocation is along the west side for a distance of about 3 miles, and extending into Section 4. The part of this work included in Section 3 is practically completed. Some particularly heavy rock excavation and earth cutting were encountered, as the railway here climbs the Niagara escarpment. The location of the line at this point was a difficult matter on this account. Over 500,000 cu. yds. of material have been removed from this cutting within a length of 1½ miles.

There is also a diversion of the main double-track line of the G.T.R. to Niagara Falls. This line crosses the right-of-way at the foot of Lock 4. The diversion has required the erection of a bridge of 4 truss spans, already supplied and erected by the Hamilton Bridge Works Company. This diversion is only temporary, and the bridge will be removed when the canal is nearing completion, whereupon it will be available for use elsewhere. The pier for the ultimate structure is to form a part of the centre wall of twin Lock No. 4. The final bridge will consist of a bascule lift span on either side of this pier. This diversion allows free passage for the excavated material from the lock pits to the stone crushing plant, and to Port Weller. In order that the diversion might be finally disposed of and cause no further trouble to the Grand Trunk Railway or to the contractor, the centre pier upon which one end of the steel spans rest has been sunk through earth and rock, a depth of 90 ft., to the level of the foundations of the locks, and, as stated, it will be eventually incorporated in the centre wall of the locks. The side piers have been sunk to about two-thirds of this depth, to the surface of the rock below. This will allow the contractors to excavate the lock pit completely and the lock walls to be built without interfering with the bridge. It will be noted that instead of building double-track spans, two single-track spans have been constructed, the idea being that they will be more easily disposed of, upon the completion of the work, than a double-track structure.

In addition to the above, which in reality calls for two bridges, the contract includes the substructures for four others. One of these is bridge No. 7 on the St. David's-Thorold Road in Thorold. It consists of a reinforced concrete bridge 99 ft. in length, and a double bascule bridge over the canal. The contract requires the complete construction of the former and the foundations for the latter. The Hamilton Bridge Works Company has recently finished the erection of a steel bridge for the Welland division of the Grand Trunk Railway. This consists of two deck plate girder spans and one through girder span. It is located close to the guard gates above Lock No. 7.

Fig. 9.—Department's Main Crushing Plant, Section 3.

A highway bridge, No. 8, over the railway cutting at Peter Street, Thorold, will consist of a bascule lift bridge, 80-ft. span, over the canal, and a reinforced con-

crete bridge of 3 spans, each 36½ ft. c. to c. of piers, over the G.T.R. right-of-way. It has a 16-ft. roadway and 6-ft. sidewalk.

Bridge No. 9, for the Niagara, St. Catharines and Toronto Railway, will be a swing span of 222 ft. 11 in., with a reinforced concrete skew approach, the centre spans of which are 46 ft. 9 in. c. to c., while the end spans next and farthest from the canal bridge are 11 ft. 7 in. and 28 ft. 6 in. in length respectively.

These bridge structures and diversions are really incidental to the general scope of the contract, and have been mentioned first as the work they involve is encountered at an early stage. There are about 3,500,000 cu. yds. of earth, 2,500,000 cu. yds. of rock and 1,500,000 cu. yds. of concrete masonry on this section. The 3 twin locks in flight are to be built, the lower end of twin Locks No. 4 being located under the Grand Trunk Railway main line, where the 4 large steel spans noted above carry the diverted railway. These three locks will lift a vessel 139½ feet to a regulating basin which will be formed by a large dam now in course of construction, on the east side at the head of Lock No. 6. Above this pond will be built single Lock No. 7, the head of the lock being located at Peter Street in Thorold, where a swing bridge crosses the present canal at the head of Lock 24.

The dam at the head of Lock No. 6 is an interesting and important part of the section. It is of earthen construction, having a concrete core wall extending from the rock surface to an elevation about 30 ft. below the top of the dam. The latter will be 75 ft. in height at its highest point, and the core wall is built in a trench in the clay overlying the rock, varying in depth from 5 to 30 feet. The good earth from the excavation has been dumped on either side of the dam site, and is now being re-handled into the work. The seat of the dam was carefully prepared by removing all loam and other loose material and by benching all sloping surfaces. A toe trench was then excavated along the full length of the dam for a few feet in depth into the solid material, and the dam has been built up in layers of approximately 8 to 12 in., each layer being carefully spread, watered and compacted by rolling. This process will be continued to the top. A heavy stone talus consisting of rock from the excavation will then be placed on the downstream side of the dam to add weight and to prevent sliding, and earth will be dumped on the upstream side after the water has been let in, to reduce the depth of water in the pond to about 10 or 12 feet.

The construction of this core wall and watertight embankment will provide a pondage covering 84 acres, for Lock No. 6. The core wall, which has been completed, is irregular in alignment. For a distance of approximately 500 ft. it projects from the canal wall at an angle of 45°. Then its direction changes through an angle of 49°, and for a distance of about 675 ft. it extends outward from the canal and at nearly right angles to it. The centre line of the dam extends from the terminus of the core wall at this point at an angle of nearly 30° for a distance of about 400 ft. where a backward sweep of about 67° occurs. This new line is followed for the remaining portion of the embankment, approximately 650 ft. The thickness of the core wall varies from 5 to 10 ft., depending on the depth, tapering at the top with a batter of 1 to 6 to a uniform width of 3 ft. At any vertical cross-section the thickness is uniform from the taper to the base of the wall.

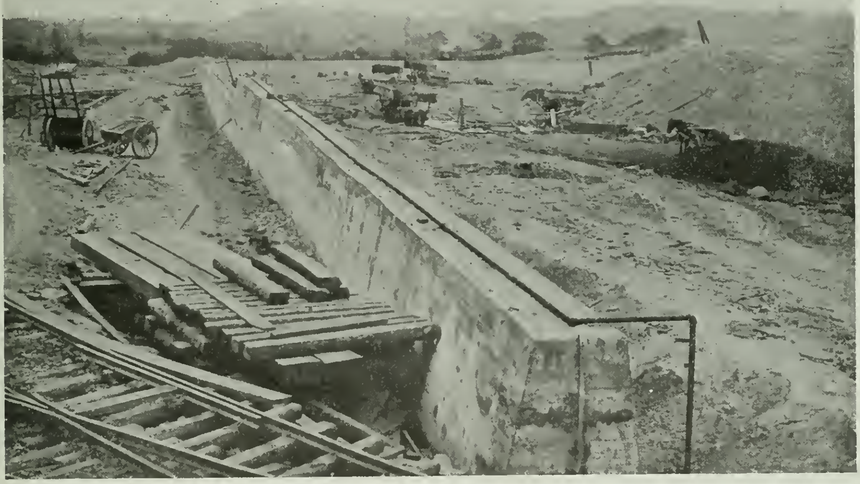

Fig. 10.—Core Wall of Dam at Head of Lock No. 6, Section 3.

Two drag-line excavators are re-handling the material that has been dumped along the side of the proposed dam from the stripping of the site of the flight locks, and from railway cuttings in the vicinity. The watertight embankment has been completed to a depth of about 6 ft.

It should be stated that the location of these flight locks, as well as the diversion of the Welland division of the G.T.R., is in the heart of the town of Thorold and

that these undertakings have involved the removal of a number of houses. The stripping has been done and at present Keystone and Cyclone drills, operated by electricity, are working on the site of Lock 5, drilling blast holes from 30 to 40 feet in depth into the rock.

The contractors for this section of the canal are required to provide crushed rock for the concrete work, not only for this section but for Sections 1 and 2. This has necessitated the installation of a large rock-crushing plant which is located east of Merritton and north of the G.T.R. line. The capacity of this plant is such as to provide 2,000 cu. yds. of crushed rock per day for each of Sections 1 and 2, besides the amount required for Section 3. The arrangement is described more fully later, in connection with the construction railway.

Fig. 11.—Reinforcing Work for the Supply Weir. Section 4 A.

Section 5.—The contract for this section was let to the Canadian Dredging Co., Midland, Ont., on December 22, 1913, the price being approximately $1,950,000. The section is about 2½ miles in length, from Sta. 636 to Sta. 774. It consists of widening the present canal between Allanburg and Port Robinson and dredging the channel to the proper depth of 25 ft. The widening is being effected by removing the west bank of the present canal. The contract calls also for the foundation work for one bascule lift bridge over the canal at Main Street, Port Robinson. It will have a span of 200 ft.

Up to September 30, 1914, the contractors had handled about 700,000 cu. yds. of excavation. Five steam shovels have been steadily employed on the work all summer. The material is being disposed of on dumping grounds provided on the west side between the present and old canals, opposite Section 4. Provision is made there for dumping the entire excavation from Section 5, which will aggregate about 5,000,000 cu. yds., practically all earth.

Section 4 A.—The contract for this division of the work was awarded on May 6, 1914, to Maguire & Cameron, St. Catharines, Ont., at about $80,000. It consists chiefly of the construction of a supply weir near the boundary of Sections 3 and 4 to furnish water to the old canal through an existing channel connecting with the present canal. Two culverts for drainage purposes under the dumping grounds mentioned above are also necessary and included in the contract.

Construction Railway.—As mentioned elsewhere, a double-track standard gauge construction railway has been built on the west side of the canal. As noted above, the contractor for Section 3 supplies the crushed stone required for the three sections, there being plenty of rock on Section 3, but none on Sections 1 and 2. A short distance from the crushing plant, track scales are being constructed which will weigh a train of cars 150 feet in length. These scales will weigh all the crushed stone leaving the plant for Sections 1 and 2. When the contractors for these sections require it, they will send their cars to this source of supply and the cars will be loaded by the contractor for Section 3. It is expected that the big plant will be in full operation within a few weeks.

The railway extends from these scales to Lake Ontario, a distance of about six miles. It is carried over the present canal, about a mile north of the crushing plant, by means of a double-track steel swing bridge, recently completed. It was built, and is maintained by the Department of Railways and Canals, under whose direction a superintendent, dispatchers and switchmen control all the operations on the road. The contractors for Sections 1, 2 and 3 are entitled to the free use of this road for the purpose of moving crushed stone from the crushing plant to their respective works, and for the purpose of removing excavated material from their respective works to the service ground fills in Lake Ontario. A complete interlocking plant and block signal system is being installed. The ballasting of the line was done by the contractors for Section 2.

Near the shore line the railway branches and each harbor embankment has its own tracks, supported by temporary wooden pile trestles that are being built out into the lake in advance of the dumps. In order to give the piles of these trestles a firm bearing and more stability than would ordinarily be the case, under-water embankments are being built in advance of the trestles. These are formed by dumping the scows of excavated material from the dredges on the line of the trestles till the scows will no longer float over it, and through this dump the piles are driven.

Up to September 30th approximately 2,500,000 cu. yds. of excavation had been transported to the harbor embankment since the completion of the railway to this point.

Sub-contracts.—The Dominion Dredging Company have sublet several portions of their work in connection with Section 1. The locks, retaining walls and other concrete work has been let to Lane Bros., while the J. H. Tromanhauser Co., Toronto, has the construction of the 55 cribs for the entrance piers and gate yard slip. On Section 2 Baldry, Yerburgh & Hutchinson have sublet portions of the excavation work to Yale & Reagan, Chicago, Ill; Hill-Leonard Engineering and Construction Company, Toronto, and to Stein & Reade, Merritton, Ont. The construction of embankments has been sublet to Michael Conroy, Chicago, who has about 50 mule teams on the work. Jos. Battle, Thorold, Ont., has already finished a small concreting sub-contract; Ernest Bennett, St. Catharines, will construct a number of culverts, while Jos. Riley, St. Catharines, has the contract for sodding the finished slopes of the canal in Section 2. As the work proceeds on the several sections the slopes are being

sodded. This will tend to prevent washing out and thereby materially reduce the cost of maintenance of the canal, besides adding to the appearance of the canal banks.

No contracts have been sub-let on Section 3. On Section 4 A, the 2 culverts will be built under sub-contract, while on Section 5, J. H. Corbett & Company, of Moncton, N.B., has the dry excavation work.

Synopsis.—The general dimensions of the canal are as follows:—

Length, lake to lake	25 miles
Bottom width	200 feet
Width at water line	310 feet
Depth of canal	25 feet
Depth on lock sills	30 feet
Number of lift locks	7
Usable length of locks	200 feet
Usable width	80 feet
Height of lock walls above sills	81.5 feet
Lift of each lock	46.5 feet

All the work is being executed under the direction of J. L. Weller, C.E., Mem. Can. Soc. C.E., chief engineer of the canal for the Department of Railways and Canals, Ottawa.

STEAM TURBINE POWER PLANT AT KAMLOOPS.

THE city of Kamloops, B.C., has recently completed a municipal power plant which, while it is smaller than some other Canadian municipal plants, differs in some respects from the ordinary steam turbine plant because of a combination of conditions which controlled the design.

The following description of the plant, written for the "Municipal Journal" by H. W. Beecher, M.E., will be found of interest:—

The city, which is located at the junction of the North Thompson and South Thompson rivers, and is on the Canadian Pacific Railway, has been growing rapidly and promises to continue to do so, and this has required provision for water supply and street lighting plants of much greater capacity than were originally constructed. The water supply is drawn from Thompson river and pumped to reservoirs on neighboring hills. Several years ago it seemed to city officials that this offered an excellent opportunity for combining pumping and electric power plants, the former being used to fill in the times between peak loads and thus keep the load more uniform. H. K. Dutcher, of Vancouver, was employed to report upon the proposition, and located a power site on the Barriere river about forty miles north of Kamloops, where an ultimate development of 16,000 h.p. was possible. The municipality voted $475,000 for the project and proceeded to carry it out. The present plans call for only 2,200 h.p. installation, but provision is made for the ultimate development of the entire power available.

The plant on the Barriere river now nearing completion will consist of two 1,100 h.p. Victor-Francis turbines made by the Platt Iron Works Company, of Dayton, Ohio, and supplied through Charles C. Moore & Co., engineers, of Seattle; and two Westinghouse water wheel type generators direct connected to the turbines. The turbines will operate at 720 r.p.m., will be of the single-runner scroll-case Francis type and will be provided with outside gate mechanism and direct-acting Lombard governor.

To provide for accidents to the power plant, and especially on account of the long transmission line, it was considered necessary to install an auxiliary steam plant in the city. As the demand for increased power was immediate, and the steam plant could be constructed more quickly than the hydraulic works, it was decided to build the steam plant as quickly as possible so that it could be used while waiting for the completion of the hydro-electric system. The engineers prepared plans for a combination steam plant, sub-station and pumping plant, and this has recently been completed and is the most interesting feature of the municipal installation.

On account of the shifting bed of the Thompson river, it was considered advisable to construct the main power house some distance from the river, where suitable foundations could be secured, and place an auxiliary pump house at the river's edge. The plan provided also for the future construction of filters to receive the discharge from the auxiliary pumps, from which the effluent could flow by gravity to the pump well of the main pumps.

The auxiliary pump house contains two vertical centrifugal pumps operated by vertical motors placed above the highest known water level. Water is brought to the pumps through long intake pipes which terminate in a screened inlet located in the middle of the river. The inlet pipes terminate at the pump house in gate valves, hand-operated. After leaving these pipes the water passes through a double system of screens into the suction chamber. The pumps are operated from the main switchboard, one by a standard hand-operated starter and the other by an automatic patent starting device controlled by a float switch which maintains at a given level the water in the suction chamber. By proper regulation of the inlet valves this automatic pump is kept in practically uniform service. The pump house is of concrete heavily reinforced throughout.

Power House and Plant.—The main building is of reinforced concrete, 90 x 75 feet ground plan, divided into boiler room, turbine room and high-tension sub-station. In the basement at the extreme west end is located a reservoir from which the pumps take their suction, and here also are located the condenser and condenser auxiliaries. The basement under the turbine room is on the same level as the boiler room floor. The suction well is connected to the auxiliary pumps on the river's bank by about 600 feet of 6-inch mains. The roof over the boiler room is supported by trusses and that over the turbine room and switchboard by deep web I-beams. The horn gap structure for the high-tension lines allows them to come in through roof cones, well within the confines of the plant.

The boiler room contains four Babcock & Wilcox water tube boilers of 250 h.p. each. Each boiler contains ten sections of ten 4-inch by 18-foot tubes, mounted under one 54-inch steam and water drum. They are designed to operate at 160 lbs. pressure. The pumps were manufactured in the Renfrew, Scotland, factory of the Babcock & Wilcox Company, and are arranged so that superheaters can be added later if conditions warrant. Shaking grates for hand firing are used, but the plant can readily be converted to an oil-burning plant. Coal is brought direct from the mines in bottom-dump cars and dumped from an overhead spur into the coal bunkers just outside the building. From the bunkers it runs by gravity onto the firing floor through chutes in the rear wall of the boiler room, from which point it is fed by hand into the furnaces. Ashes are raked into the boot or hopper of a motor-driven conveyor elevator of the endless chain type, which discharges them on the ground about 40 feet east of the boiler room. The chimney is 89 inches in diameter and 180 feet high above the boiler room floor. It is

heavily reinforced with ⅝-inch steel rods and is of the tapering or coniform type. The boiler feed pumps are of the Smith-Vaile outside end packed plunger type, 6 x 4 x6 inches, manufactured by the Platt Iron Works. They receive water from a Stilwell open type heater. This type of heater is advantageous because it permits the settling out in the filter beds in the bottom of the heater of sediment contained in the river water which is used for boiler purposes. In the heater the water drips over a large tray surface and then passes into the settling chamber and filter.

The boiler branches leading from the four boilers are each provided with automatic steam stop and check valves at the boiler nozzles and a double wedge gate valve at the header. The header is carried on the boiler room side of the partition between that and the turbine room, branches to the turbine being carried through openings left in the concrete wall. Gate valves are placed on each turbine branch. An auxiliary header is installed within the turbine room, from which branches are carried down to the air pumps and circulating pumps.

The generating equipment consists of two Curtis turbo-generators of 600 kw. capacity built by the General Electric Company. They are wound for 2,200 volts three-phase 60-cycle and operate at 3,600 r.p.m. The governor mechanism operates six inlet valves, giving very close speed regulation. Each unit has an electric speed-changing device and over-speed safety trip. The speed of the turbo-generator is thus controlled by the switchboard operator, materially facilitating the paralleling of the machines at the time of bringing the machine onto the line. A 20-kw. G.E. motor generator exciter running at 1,200 r.p.m. is provided, and for breakdown service and for starting a 15-kw. Curtis steam turbo-generator exciter.

The turbines exhaust through corrugated copper expansion joints into cylindrical surface Wheeler condensers equipped with steam turbine-driven circulating pumps and Edwards suction valveless air pump. Each condenser contains 1,440 square feet of cooling surface of ¾-inch brass tubes, secured in brass sheets by ferrules and packed joints. The air pumps are single cylinder, single acting, 7-inch steam cylinder and 16-inch air cylinder with 10-inch stroke. The suction valveless feature makes it possible to use the one pump for handling both air and condensate and maintain a high vacuum. The condensed steam and non-condensible vapors flow continuously by gravity from the condenser to the base of the pump and are removed by a conical piston, which projects the water without shock at high velocity through ports in the sides of the working barrel. The condensing equipment is arranged to produce between 28 and 28½ inches of vacuum and was furnished by the Wheeler Condenser and Engineering Company.

Waterworks Equipment.—The waterworks pumping plant consists of two Platt 2-stage centrifugal pumps of the horizontal split casing type, fitted with bronze runners and arranged for motor drive. Their efficiency is 72 per cent. They are driven by two 200 h.p., 1,760 r.p.m. induction motors manufactured by the Canadian General Electric Company. A third pump, manufactured by the Platt Iron Works, is steam-driven, of the 2-stage type, operated by a 200 h.p., 2,200 r.p.m. Kerr economy type condensing turbine, exhausting into a Wheeler waterworks type condenser with Edwards air pump. The condenser has 1-inch tubes and is placed in the suction of the pump so that no circulating pump is necessary. Each of these three pumps has a capacity sufficient to supply the city consumption if operated twenty-four hours a day, but all three can be operated at once, the large reserve capacity being considered advisable to insure adequate fire protection in the business section. Each pump has a capacity of 1,200 Imperial gallons per minute against a head of 350 feet.

The steam turbine-driven pump is found to be very economical, owing to its being operated condensing, the greatest efficiency being obtained with 28 inches vacuum.

Water from these pumps is discharged into a reservoir about a mile away and about 320 feet above the pumps. The main between pump and reservoir serves also as distribution main.

The discharge from the pumps is measured by a Simplex venturi meter located just outside the building wall, the recording and integrating apparatus being placed in the corner of the turbine room.

There is an elaborate switchboard of natural slate containing 22 panels. All high-voltage connections on switchboard leads which would prove dangerous to the operators are on a structure placed some distance to the rear of the switchboard and operating by remote control. There is no apparatus on the panels at a potential above 110 volts. The switchboard consists essentially of a station lighting panel box, three generator panels (one blank as yet), 2 station power panels and 2 incoming high-tension line panels, the balance being feed panels. At the extreme end of the board are located the constant current panels for controlling the constant current tubs on the series arc lighting system of the town. The voltage on the system is kept constant by a Tirrell automatic voltage regulator. The high-voltage apparatus for the proposed high-tension lines from the hydro-electric plant are behind and above the switchboard, partitioned off from the rest of the equipment. It consists essentially of oil switches, aluminum lightning arrester and static transformer, which reduces the voltage from 44,000 to 2,200. Under the transformer are provided suitable oil tanks and water piping to cool the oil in the transformer.

A 10-ton hand-operated traveling crane which runs over the entire turbine and pump room is provided for handling heavy machinery parts. A transfer car permits the transformers to be wheeled out under the crane to facilitate handling their cores for inspection or repair.

This plant, during the short time which it has been operated, has shown a material saving of fuel as compared to the old plant which it supplants. A still greater saving is anticipated when the new hydro-electric plant comes into service and the steam station is held as an auxiliary only.

HUMIDITY OF COAL MINE AIR.

The fact that dry bituminous coal dust will explode under certain conditions has been proved both by the experience of the past and by laboratory tests and is now generally admitted by all coal men.

That coal dust may be rendered inert by the proper application of moisture has been shown both by laboratory tests and by the absence of explosions at mines in which moisture is present in the proper proportion to the quantity of dust produced. The result of an investigation in Illinois, of the humidity of mine air, carried out by the United States Bureau of Mines, leads to the belief that steam may be applied to the intake air in such a way as to offer the most economical and efficient method of dampening coal dust.

The Panama Canal was closed to traffic five days, October 15-20, by a landslide in Culebra Cut. Fifteen ships were detained one or more days each, and will have claims on the government for demurrage.

DESIGNING SMALL WATERWORKS SYSTEMS.*

By William S. Johnson.

IN Massachusetts there are 215 water supply systems, and of these, 152 were installed before the population of the towns they supply was 5,000, and 111, or more than half, are now still supplying towns of less than 5,000. In fact, the opportunity seldom comes to design a complete system of works for a large community, the larger systems being extensions of the system designed for the small town. As there are only four towns in Massachusetts having a population of more than 3,000, which remain unsupplied with water, it is likely that, in that State at least, the problems arising in small systems will be more numerous than the problems connected with the larger systems, although, perhaps, not so interesting to any but those immediately affected.

It has been my lot to put in a number of small waterworks plants, and it has surprised me to see how easily 10 per cent. of the cost of construction may be saved by a thorough study of the problem. I have also found that many problems over which I have worked have been solved by others, who have kept the results to themselves, not because of unwillingness to part with the information, but because the matter seemed too small to be of general interest. It is with a view of encouraging the discussion of the problems connected with small waterworks installations, as well as to give a few of the results of my own experience that this paper is presented.

Provision for Future Requirements. — The works should be designed for a long time in the future, but the design should provide for as little immediate construction as is possible except where the cost of extensions or increased capacity will be much more than the cost of doing the work in the beginning.

To build works for a long time in the future assumes a power of prophecy which most of us do not possess. It is impossible to foretell the future growth of the whole or any part of the community. The advancements in the art of water supply engineering are so rapid that portions of the plant are likely to become obsolete before they are worn out. The requirements of the public which uses the water are changing very rapidly. For these reasons it is desirable to build only for the immediate future, and to plan for additional works to be constructed as they become necessary.

Fire Protection Requirements.—The capacity of the distributing system is determined, in the case of the small town, by the fire-protection requirements solely. One good, effective fire stream will use water at as great a rate as the ordinary town of 5,000 inhabitants will require for domestic purposes during the hours of maximum draft.

The quantity of water which will be drawn from the sources of supply depends upon the population to be supplied, the character of the residences supplied, the care taken to prevent leaks and other wastes, and the use of water for manufacturing or mechanical purposes. It is exceedingly difficult to evaluate these factors, since it is impossible accurately to forecast the industrial development or retrogression of the average small community. The population to be served depends primarily upon the growth of the community's industries. A future per capita domestic consumption of from 75 to 100 gallons per day for ordinary small towns does not seem unlikely, and in the case of towns having large estates and a large area of well-kept lawns the consumption may be much larger.

Metcalf, Kuichling and Hawley, in a paper before the American Waterworks Association, state that "the cost of the portion of the waterworks plant involved by fire protection probably constitutes from 60 to 80 per cent. of the entire cost of the physical property in the case of communities having less than 5,000 population." This is undoubtedly true except in those places where it is necessary in order to secure water of sufficient purity for domestic purposes, to go to a large expense in obtaining it or in its purification.

In a small town it is usually necessary to depend entirely on hydrant streams without the use of steamers, and it is essential, therefore, that the works, either by themselves or assisted by some outside source, should furnish both the requisite quantity of water and the proper pressure with which to fight the greatest conflagration which is likely to occur, and to do this under the most unfavorable conditions in regard to domestic consumption and quantity of water in reservoir or standpipe.

Fire Streams.—The standard fire stream is now considered to be that thrown by a 1⅛-inch smooth nozzle, discharging 250 gallons per minute, and it is generally considered by the insurance engineer that a hose stream which does not throw 200 gallons per minute is not a good stream. There are many cases, however, where smaller streams throwing from 150 to 175 gallons per minute would furnish reasonable protection, and this is all that a town would be justified in providing in some districts. In the outlying sections of small towns any fire which gets sufficient headway in the ordinary building so that it cannot be controlled with two streams of 150 to 175 gallons each is not likely to leave much of value if it is extinguished by using six streams. In such cases the value of the water is chiefly in saving adjacent buildings, and for this purpose even small streams are of great value. For streets in a district where the houses are small and occupy comparatively large lots with no prospect of any considerable increase in density of population, and where extensions of the mains are not likely, a hydrant which will furnish 300 gallons per minute under a suitable head to any building in the territory supposed to be covered by this hydrant will be good fire protection. More is desirable, but the advantages are not sufficiently great to warrant the expense of larger mains to secure it. In a district where the houses are nearer together, but where there are no business blocks, apartment houses or other large buildings, it should be possible to get 500 or 600 gallons per minute at any point. Where there are business blocks and other large buildings and where the buildings are very close together, as they frequently are in the centre of a small village, it should be possible to get 1,000 gallons per minute. Where there are factories or other special fire risks a much larger quantity may be necessary, and a special study should be made of each case.

Pressure and Hydrant Spacing.—The pressure required at the hydrants while the hydrants are being used should be great enough to force the water through the greatest length of hose which will be used and throw it to a sufficient height to cover any building. The hydrant spacing and the pressure should, therefore, bear some relation to each other. Table I., from E. B. French, gives the limit of a good, efficient fire stream with different lengths of good, rubber-lined cotton hose, with a constant pressure of 60 lbs. at the hydrant, with moderate wind. Table I. also gives the corresponding amount of water which would be discharged.

* Read at a meeting of the New England Waterworks Association.

Table I.—Height and Volume of One $1\frac{1}{8}$-Inch Stream Flowing from a Smooth-Bore Nozzle.

Length of hose, ft.	Limit of height, ft.	Discharge, gals. per min.
100	67	250
200	59	222
300	52	206
400	44	188
500	40	178
700	33	158
1,000	25	140

Table I. shows the importance of having hydrants near the buildings to be protected. Unless the hydrants are near enough to furnish water at the fire under a good pressure, the expense of large pipes and a high reservoir is largely wasted. The cost of a two-way hydrant in place is about $40, and in the ordinary distribution system about eight hydrants are required per mile of street main to keep the hydrants within 250 feet of every building in the territory covered; so that the expense of hydrants is very small compared with the expense incurred in other parts of the system to obtain efficient fire protection. In general, hydrants should not be more than 500 feet apart in the outlying sections. In the more closely built-up sections they should be so spaced as to make it possible to get the number of streams which are considered necessary at any particular point with the use of not more than 300 feet of hose for each stream. This figure may be modified, however, if the pressure is unusually high, and should be if the pressure is unusually low.

The minimum pressure desirable for good fire protection with hydrants spaced as suggested is about 50 pounds per square inch at the hydrants when they are in use. This pressure will give, with 300 feet of best quality hose and a $1\frac{1}{4}$-inch nozzle, a stream of 185 gallons per minute, which can be thrown to a height of 44 feet. With 200 feet of hose the quantity thrown would be about 200 gallons per minute, and the height would be increased to 50 feet. There are cases where in the higher sections of the town these pressures are almost impossible, and in such places the hydrants should be so located as to require as little hose as possible. In the case of thickly built-up villages, the pressure should be 60 pounds per square inch at the hydrant when the water is being drawn at the maximum rate. This pressure will give a stream of more than 200 gallons per minute with 300 feet of hose, and with 200 feet of hose will throw 222 gallons per minute to a height of about 60 feet.

Size of Mains.—The size of the mains depends entirely on the requirements determined on to give fire-fighting facilities and on the head available. When these are known the system can readily be designed. Generally, however, the head which can be secured is not fixed, but can be made whatever is desired by going to additional expense, and the determination of the most economical arrangement of height of reservoir, size of pipes and spacing of hydrants is a matter for careful study. The rule adopted in many places to put in no street main less than 6 inches in diameter in most cases works out properly, but there is no excuse for it as an arbitrary rule. A short street will many times be better served with a 4-inch pipe than other streets in the same system with 6-inch mains, and the money saved by using the smaller pipe could well be expended in strengthening those parts of the system which are weaker. The standard should be the quantity of water the pipe will deliver and the head under which it delivers this amount. If a 4-inch pipe will do this satisfactorily, there is no good reason why it should not be used.

The loss of head due to friction in a 6-inch pipe which has been in the ground for some time, when water is being drawn at the rate of 300 gallons per minute, is about 10 feet per 1,000 feet of length, and this figure, together with the required pressure at the hydrant of 50 pounds per square inch, should, in general, determine the allowable length of 6-inch pipe as a dead end.

The maximum desirable pressure is a matter on which there is much disagreement, but the limit is constantly being extended. If it should prove to be more economical to have a system where the pressure runs up to 150 pounds, there would seem to be no good reason why this should not be done in a new system of waterworks, and it would be likely to prove much more satisfactory than to maintain two levels. In 86 small towns in Massachusetts the average static pressure in the central portion of the town is 79 pounds per square inch. Nine of these towns have pressures of less than 50 pounds; 33 have pressures of from 50 to 75 pounds; 21 from 75 to 100 pounds, and in 13 the pressure is more than 100 pounds.

Pumping Engines.—The development of the oil and gasoline engine has done much to make waterworks systems for small places financially possible. When the only available pumping machinery was the steam pump, the cost of installation of pumps and boilers, the cost of the pumping station to house them, and the cost of maintaining the plant made waterworks practically out of the question unless a gravity supply could be secured. With the new form of engine, however the conditions are quite different. The cost of the machinery has been greatly reduced, the cost of the station is much less, and the cost of operating is reduced to a minimum on account of the fact that with oil or gasoline there is no consumption of fuel except while work is being done, while with a steam plant a large proportion of the coal is used in banking the fires and getting up steam. Electricity is also becoming an important factor in connection with small pumping plants, although the cost of current is so great (in New England) that there are few places where oil or gasoline are not more economical except for auxiliary plants used only occasionally.

Pumps should usually be designed for the greatest economy in doing the work which they are called upon to do regularly in supplying the domestic needs of the town without regard to their use for fire protection purposes. It is seldom feasible in the small system to have pumps of sufficient capacity to be of very great value in case of fire, and dependence for fire protection should be placed on water stored in a reservoir or large standpipe or tank, or on some connection with factory pumps through which a large supply of water can be quickly secured. With increased size of pumps it is necessary to have a larger force main, a larger suction pipe, more wells, if the supply is taken from driven wells; in fact, a considerable portion of the plant must be increased in size and made more expensive in order to operate large pumps. Large pumps are somewhat more efficient than small ones, and if an attendant remains at the station while the pumps are in operation there is a saving in the shorter hours required with the large pump. With the oil engine, however, or with electricity, constant attendance is unnecessary, especially in the case of the smaller plants.

Pumping machinery should always be provided in duplicate, and works, although designed to run most

economically when one unit is in operation, can be operated, if necessary, at double capacity with a somewhat reduced efficiency. A plant designed for a community which will use from 100,000 to 150,000 gallons per day, should generally have a capacity of about 250 gallons per minute for each unit. This would mean the operation of one of the pumps for from six to ten hours each day. Such a plant would give two large fire streams in case of fire by starting both of the pumps. Many pumping plants are undoubtedly of too large capacity for economy, and the tendency in recent years has been to make them smaller, especially when the power used is some form of internal combustion engine.

Distributing Reservoir.—The design of the distributing reservoir is affected chiefly by the topography, the requirements for fire protection and by facilities for pumping. In a much less degree it is affected by the consumption of water. The effect of the topography upon the design is generally to change the reservoir from what is desirable to what is practicable. In a comparatively flat community it is practically impossible to store as much water at so great an elevation as is desirable, and in such cases the distributing reservoir must be cut down and other portions of the system must be designed to do the work which should properly be done by the distributing reservoir.

When the topography is such that it is feasible to build a reservoir of any desired size and any height, the design is dependent almost entirely upon the requirements for fire protection. Generally, it is found that the desirable static pressure from the reservoir at the point where there is likely to be the greatest demand for water is from 80 to 100 pounds, depending to a large extent upon the distance from the reservoir to the centre of distribution. The reservoir should be, if practicable, large enough to hold at the required elevation, in addition to the domestic supply for 24 hours, a sufficient quantity of water with which to fight any fire which is likely to occur. A fire in the built-up portion of a village may take about 1,000 gallons per minute, or 60,000 gallons per hour. In general, the time during which this quantity will be required will not be more than from two to four hours. Applying this rule to the ordinary town with no large fire risks, the capacity of the reservoir to standpipe should be from 300,000 to 400,000 gallons.

Pipe Thickness.—The part of the design in which theory plays the smallest part, and in which even experience is likely to count for little, is in the determination of the thickness and weight of cast-iron mains. The static pressure which pipes have to withstand and the breaking strength of the cast-iron are the only elements in determining the proper thickness of the pipes which are even approximately known, and determining the thickness from these elements alone would give pipes of about the thickness of cardboard.

The formula used by the New England Waterworks Association is:—

$$t = \frac{pr}{1/5\ (16,500)} + \frac{p'r}{1/5\ (16,500)} + 0.25$$

where t is the thickness of the shell in inches; r, is the radius of the pipe; p, the static pressure in pounds per square inch; p', an assumed water hammer in pounds per square inch; 16,500 is the breaking strength of cast-iron; and 5 is a factor of safety.

The chief uncertainties in the determination of the proper thickness of pipes are the water hammer, the effect of corrosion, the possibility of breakages in handling, the strains due to imperfect foundations or unequal settlement, and the eccentricity of castings and other imperfections in the pipe. There is no reason why the water hammer in a small system should not be kept below the figures ordinarily used in the formula. There are few, if any, authentic cases where corrosion of a cast-iron pipe has caused its failure. In fact, if a pipe has been in the ground long enough to corrode, it seldom fails from any cause. The strains due to imperfect foundation and settlement, in the case of small pipes, can be neglected if proper precautions are taken during construction. The difficulties due to imperfections in the casting and to the handling of thin pipes are the most serious, and to overcome these is the duty of the founders. That they will be overcome, if the engineers insist on light pipes, there is no doubt, for already much has been done along these lines; the cost per ton may be somewhat increased if lighter pipes are used, but this increased cost will be nothing like the saving accomplished by the use of the lighter pipe.

In my own practice I have put in many miles of Class C pipe where the pressures run up to 115 pounds per square inch and have never known of a failure which would have been prevented by using thicker pipe. The breakage in the handling may be or may not have been greater. In any case, it was not excessive. For the ordinary conditions in a small town I would never use a heavier pipe than the Class C, and lighter pipe may safely be used in many cases.

Depth of Cover for Pipe Lines.—The depth to which street mains should be laid has been investigated by a special committee of the New England Waterworks Association (see report presented at November, 1909, meeting), and the experience of the cold winter of 1911-12 has given valuable experience to those who have had charge of waterworks. The depth determined on affects the cost of the works materially, especially if rock is encountered, and if it is safe to reduce the depth it certainly should be done.

Theoretically, street mains might be laid at different depths in different soils, being a foot nearer the surface in clay than in gravel, but in the average New England town there are so many soils that it is not wise to make any distinction. The only discrimination which it would appear safe to make is in the case of places where the ground water always stands near the surface; here the pipes may be laid in shallow trenches. The freezing of the pipes is such a serious matter that it would seem to be unwise to take any chances in an attempt to save money on trench excavation. The best practice seems to be, for a climate like that of Massachusetts, to have the centre of the pipe from 4.75 to 5 feet beneath the surface.

OPPORTUNITIES FOR EXPORT OF RAILWAY MATERIAL.

German exports of rails to South Africa last year were valued at $300,000, and that of rolling stock at $120,000, according to a report of the Department of Trade and Commerce. Canada should make progress in both these items in the future. Under the item of locomotives, Germany's trade for 1913 was only $22,000. In addition to the railway material imported under the general heading, there were also imported in 1913 for the Union Government: rails, $1,315,000; sleepers, $897,000; locomotives, $570,000; rolling stock, $1,742,000, and under the item, all other, $329,000. The only line which Germany shipped was under all other, and her total was only $15,000. This year a number of locomotives and cars were ordered in Germany and under normal conditions she would have figured both this year and next in the Union Government's imports.

TRANSMISSION LINE CHARACTERISTICS.

By E. Maerker, A.Sc.
Designing Structural Engineer, Toronto.

(Continued from October 15th issue.)

An article on transmission line characteristics by the same author appeared in the issue of October 15th, dealing with 250,000 C.M. copper wire and 400,000 C.M. aluminum wire, both for 600-ft. spans. In transmission line work the standard span (of, say 600 feet) cannot always be adhered to, due to river crossings, railways, highways, etc. For this reason a chart comprising various spans would be of great value. Furthermore, since Charts I. and II., in previous issue, give a complete picture of the behavior of the wire under different loadings and for different temperatures, a chart with no ice and no wind acting on the wire, would be more useful for stringing purposes, including, of course, the usual range of temperature.

Chart III. has been drawn up for this purpose for a 250,000 C.M. copper wire, ranging from a 200-ft. span to a 1,000-ft. span, with no ice and no wind acting on the wire. It is to be understood that all these spans pull up to 5,900 lbs. at 0° F. with ½ inch of ice and 8 lbs. per square foot of wind pressure on the wire, as explained in previous article. In Charts I. and II. the points of intersection were solved graphically by assuming values for S_1, the sag, and computing the corresponding values for P_1, the tension. In Charts III. and IV. all points of intersection will have to be solved algebraically and then plotted.

Following equations of previous article are employed:

Modified equation (2) $L_1 - L_0 = L_0 \alpha t + \dfrac{P_1 - P_0}{a E} L.$

Equation (4) $P_1 = \dfrac{w_1 l^2}{8 S_1}$

Solving for P_1 in the former equation, we have:

$$P_1 = \frac{L_1}{L_0} a E - [a E (1 + \alpha t) - P_0]$$

and substituting for L_1 and L_0 its equal $l + \dfrac{8 S_1^2}{3 l}$ and $l + \dfrac{8 S_0^2}{3 l}$ respectively, we obtain:

$$P_1 = \frac{3 l^2 + 8 S_1^2}{3 l^2 + 8 S_0^2} a E - [a E (1 + \alpha t) - P_0]$$

$$= \frac{3 l^2 a E}{3 l^2 + 8 S_0^2} + \frac{8 S_1^2 a E}{3 l^2 + 8 S_0^2} - [a E (1 + \alpha t) - P_0]$$

but $S_0^2 = \dfrac{w_0^2 l^4}{64 P_0^2}$ and substituting this in above:

$$P_1 = \frac{3 l^2 a E}{3 l^2 + \dfrac{w_0^2 l^4}{8 P_0^2}} + \frac{8 S_1^2 a E}{3 l^2 + \dfrac{w_0^2 l^4}{8 P_0^2}} - [a E (1 + \alpha t) - P_0]$$

Rearranging and simplifying terms:

$$P_1 = \frac{a E}{\dfrac{l^2}{8}\left(3 + \dfrac{w_0^2 l^2}{8 P_0^2}\right)} S_1^2 + \frac{a E}{\dfrac{1}{3}\left(3 + \dfrac{w_0^2 l^2}{8 P_0^2}\right)} - [aE (1 + \alpha t) - P_0]$$

Eliminating P_1 by using equation (4):

$$\frac{w_1 l^2}{8 S_1} = \frac{a E}{\dfrac{l^2}{8}\left(3 + \dfrac{w_0^2 l^2}{8 P_0^2}\right)} S_1^2 + \frac{a E}{\dfrac{1}{3}\left(3 + \dfrac{w_0^2 l^2}{8 P_0^2}\right)} - [a E (1 + \alpha t) - P_0] \quad (6)$$

Equation (6) is a reduced cubical equation of the form

$$x^3 + px + q = 0$$

S_1 being the unknown quantity. All other quantities are constants for a definite span and temperature.

Table VII. has been compiled to solve equation (6).

$a E = .19635 \times 16,000,000 = 3,141,600$; $\alpha = .0000096$
$w_1 = .762$
$w_0 = 1.788$
$w_0^2 = 3.1969$
$P_0 = 5,900$
$P_0^2 = 34,810,000$

With these values substituted in equation 6, we are now able to solve for the sag, S_1. This is easily accomplished by trial with two sets of slide rules, as follows:

Let it be desired to find the sag for a 400-ft. span at 90 degrees F. With values substituted from Table VII., equation 6 will reduce to $\dfrac{15,240}{S_1} = 52.3\,S_1^2 + 3,139,678 - 3,138,415$, and finally $\dfrac{15,240}{S_1} = 52.3\,S_1^2 + 1,263.$

With the left-hand side of the equation operated by the setting of one slide rule and the term $52.3\,S_1^2$ operated by the setting of the other, the value for S_1 will soon be found by successive trials. In this case we have, assuming $S_1 = 5.43$ ft., $\dfrac{15,240}{5.43} = 52.3 \times 5.43^2 + 1,263$ or $2,810 = 1,545 + 1,263 = 2,808$, which gives the sag sufficiently accurate.

Table VIII. has been figured accordingly and the values for P_1 computed from equation 4 $P_1 = \dfrac{w_1 l^2}{8 S_1}$.

Chart III. has been drawn up with the tension as the horizontal axis and the sag as the vertical axis. Any values for spans between those shown, can be interpolated with sufficient accuracy.

Chart III. is indispensable for the purpose of stringing wire at any temperature. It brings out a very important factor which, to the author's knowledge, has been disregarded in the construction of many transmission lines.

Coupling a 600-ft. span with a 200-ft. span, it is seen that at 120 degrees F. the tension for the 600-ft. span is 2,465 lbs., and for the 200-ft. span 2,350 lbs., a difference of 115 lbs. in favor of the longer span. At -30 degrees, the 600-ft. span has a tension of 4,110 lbs. and the 200-ft. span a tension of 6,400 lbs., a difference of 2,290 lbs. in favor of the shorter span. These 2,290 lbs. represent a dead pull along the line and too great a stress on the insulator and the supporting structure, especially if this particular tower should happen to be at an angle, in which case the insulator would have to bear the stress due to the angle in addition to the stress of 2,290 lbs., as mentioned above.

It will be noticed here that, although a maximum tension of 5,900 lbs. is specified at 0° F., with ice and wind, the tension for a 200-ft. and 300-ft. span at -30°

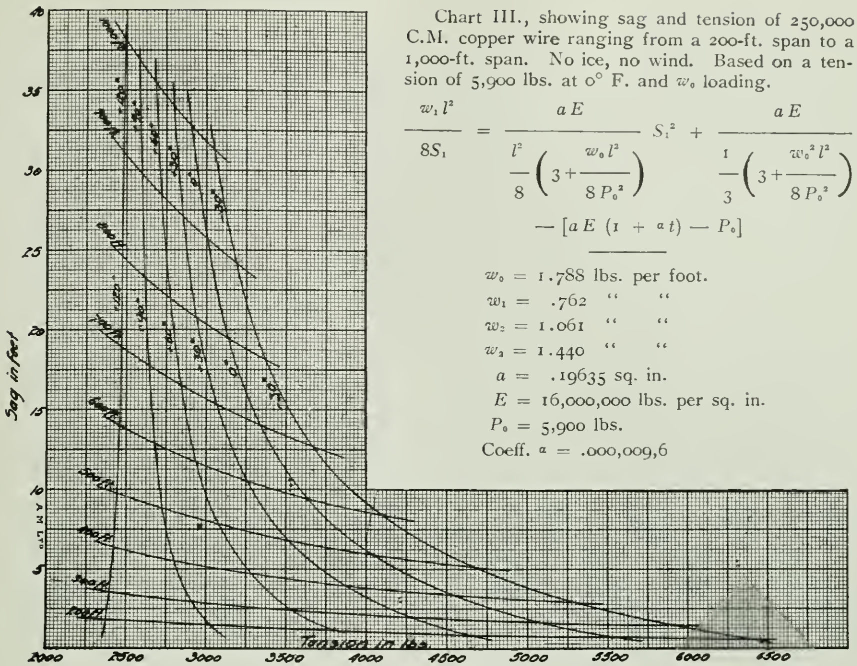

Chart III., showing sag and tension of 250,000 C.M. copper wire ranging from a 200-ft. span to a 1,000-ft. span. No ice, no wind. Based on a tension of 5,900 lbs. at 0° F. and w_0 loading.

$$\frac{w_1 l^2}{8 S_1} = \frac{a E}{\frac{l^2}{8}\left(3 + \frac{w_0 l^2}{8 P_0^2}\right)} S_1^2 + \frac{a E}{\frac{1}{3}\left(3 + \frac{w_0^2 l^2}{8 P_0^2}\right)} - [a E (1 + \alpha t) - P_0]$$

w_0 = 1.788 lbs. per foot.
w_1 = .762 " "
w_2 = 1.061 " "
w_3 = 1.440 " "
a = .19635 sq. in.
E = 16,000,000 lbs. per sq. in.
P_0 = 5,900 lbs.
Coeff. α = .000,009,6

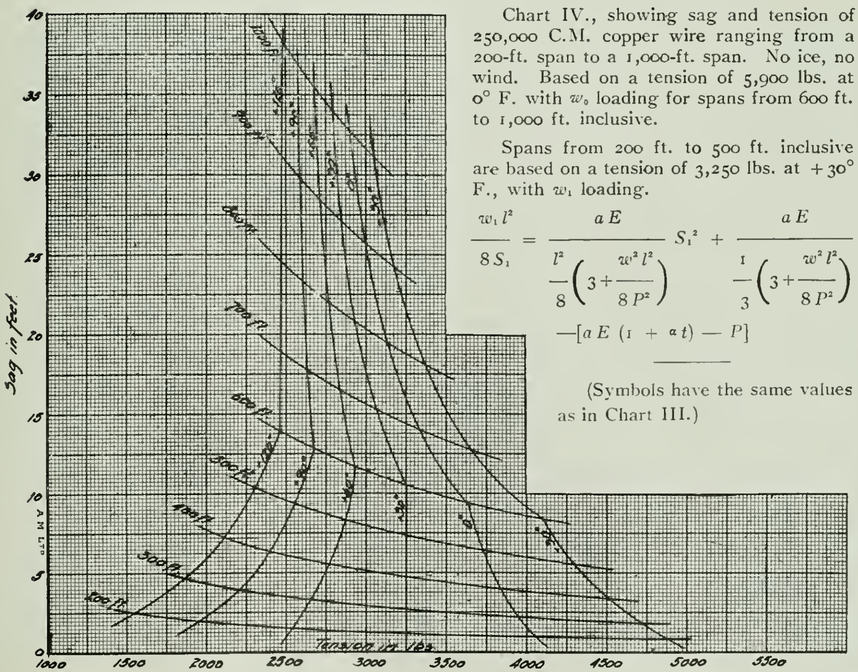

Chart IV., showing sag and tension of 250,000 C.M. copper wire ranging from a 200-ft. span to a 1,000-ft. span. No ice, no wind. Based on a tension of 5,900 lbs. at 0° F. with w_0 loading for spans from 600 ft. to 1,000 ft. inclusive.

Spans from 200 ft. to 500 ft. inclusive are based on a tension of 3,250 lbs. at +30° F., with w_1 loading.

$$\frac{w_1 l^2}{8 S_1} = \frac{a E}{\frac{l^2}{8}\left(3 + \frac{w^2 l^2}{8 P^2}\right)} S_1^2 + \frac{a E}{\frac{1}{3}\left(3 + \frac{w^2 l^2}{8 P^2}\right)} - [a E (1 + \alpha t) - P]$$

(Symbols have the same values as in Chart III.)

with no ice and no wind is exceeding this value and the computation for these two spans would have to be based on 5,900 lbs. at -30° F. with no ice and no wind. Since the stringing of all spans is usually based on the same assumption, *i.e.*, maximum tension at a low temperature under maximum loading, there is bound to be a dead pull along the line with unequal spans, as seen from Chart III. The author has seen cases where the line turned a slight angle and a standard tower was found sufficiently strong to resist this additional sidepull. However, a short span was used on one side of the tower, toward the angle, presumably to counteract the sidepull. This, of course, made matters worse and added to the pull on the insulator and tower, instead of relieving the stress.

The influence of the temperature in the tension is much greater for short spans than for long spans. It is

	-30°	0°	$+30^\circ$	$+60^\circ$	$+90^\circ$	$+120^\circ$
$aE(1+\alpha t)-P_0$	3,134,795	3,135,700	3,136,605	3,137,510	3,138,415	3,139,320

Table VII.

Span.	$\frac{w_1 l^2}{8}$	$\frac{l^2}{8}$	$3+\frac{w_0^2 l^2}{8P_0^2}$	$\frac{l^2}{8}(3+\frac{w_0^2 l^2}{8P_0^2})$	$\frac{1}{3}(3+\frac{w_0^2 l^2}{8P_0^2})$	$\frac{aE}{\frac{l^2}{8}(3+\frac{w_0^2 l^2}{8P_0^2})}$	$\frac{aE}{\frac{1}{3}(3+\frac{w_0^2 l^2}{8P_0^2})}$
200	3,810	5,000	3.0004592	15,002	1.000153	209.4	3,141,119
300	8,573	11,250	3.0010332	33,762	1.000344	93.1	3,140,518
400	15,240	20,000	3.0018368	60,037	1.000612	52.3	3,139,678
500	23,813	31,250	3.0028700	93,840	1.000957	33.5	3,138,597
600	34,290	45,000	3.0041328	135,186	1.001378	23.24	3,137,278
700	46,673	61,250	3.0056252	184,095	1.001875	17.07	3,135,720
800	60,960	80,000	3.0073472	240,588	1.002449	13.05	3,133,928
900	77,153	101,250	3.0092988	304,692	1.003100	10.31	3,131,927
1000	95,250	125,250	3.0114800	376,435	1.003827	8.35	3,129,624

Table VIII.

$$\frac{w_1 l^2}{8S_1} = \frac{aE}{\frac{l^2}{8}(3+\frac{w_0^2 l^2}{8P_0^2})} S_1^2 + \frac{aE}{\frac{1}{3}(3+\frac{w_0^2 l^2}{8P_0^2})} - [aE(1+\alpha t)-P_0]$$

	-30°		0°		$+30^\circ$		$+60^\circ$		$+90^\circ$		$+120^\circ$	
	P_1	S_1	P_1	S_1	P_1	S_1	P_1	S_1	P_1	S_1	P_1	S_1
200	6,400	.59	5,520	.69	4,650	.82	3,810	1.00	3,025	1.26	2,350	1.62
300	5,910	1.45	5,075	1.69	4,287	2.00	3,550	2.42	2,905	2.95	2,395	3.58
400	5,310	2.87	4,565	3.34	3,880	3.93	3,280	4.64	2,810	5.43	2,425	6.28
500	4,675	5.10	4,055	5.89	3,520	6.77	3,080	7.74	2,730	8.74	2,440	9.76
600	4,110	8.35	3,635	9.43	3,255	10.53	2,940	11.68	2,695	12.82	2,465	13.92
700	3,675	12.72	3,340	13.98	3,065	15.22	2,835	16.45	2,645	17.68	2,470	18.90
800	3,350	18.2	3,135	19.45	2,940	20.75	2,790	21.85	2,610	23.35	2,475	24.65
900	3,190	24.2	3,010	25.65	2,855	27.05	2,715	28.45	2,600	29.7	2,485	31.0
1000	3,045	31.3	2,905	32.8	2,790	34.1	2,685	35.5	2,585	36.9	2,490	38.2

Table IX.—Rectification of Curves.

Assumed Tension of 3,250 lbs. at + 30° F. for Spans from 200 ft. to 500 ft., Inclusive.

	$3+\frac{w_1^2 l^2}{8\times 3250^2}$	$\frac{l^2}{8}(3+\frac{w_1^2 l^2}{8\times 3250^2})$	$\frac{1}{3}(3+\frac{w_1^2 l^2}{8\times 3250^2})$	$\frac{aE}{\frac{l^2}{8}(3+\frac{w_1^2 l^2}{8\times 3250^2})}$	$\frac{aE}{\frac{1}{3}(3+\frac{w_1^2 l^2}{8\times 3250^2})}$
200	3.0002748	15,001	1.0000916	209.4	3,141,312
300	3.0006184	33,757	1.0002061	93.1	3,140,953
400	3.0010992	60,002	1.0003664	52.3	3,140,449
500	3.0017178	93,804	1.0005726	33.5	3,139,802

	-30°	0°	$+30^\circ$	$+60^\circ$	$+90^\circ$	$+120^\circ$
$aE(1+\alpha t)$ - -	3,139,790	3,140,695	3,141,600	3,142,505	3,143,410	3,144,315
$aE(1+\alpha t)-3250$	3,136,540	3,137,445	3,138,350	3,139,255	3,140,160	3,141,065

Table X.

	-30°		0°		$+30^\circ$		$+60^\circ$		$+90^\circ$		$+120^\circ$	
	P_1	S_1	P_1	S_1	P_1	S_1	P_1	S_1	P_1	S_1	P_1	S_1
200	4,880	.78	4,050	.94	3,250	1.17	2,540	1.50	1,955	1.95	1,545	2.47
300	4,715	1.82	3,950	2.17	3,250	2.64	2,655	3.23	2,200	3.90	1,855	4.62
400	4,500	3.39	3,830	3.98	3,250	4.70	2,770	5.50	2,400	6.35	2,110	7.22
500	4,285	5.55	3,725	6.40	3,250	7.33	2,870	8.30	2,550	9.33	2,305	10.32

not always sufficient to base all computations on a maximum loading at 0 degrees F., but investigate the tension at the lowest temperature with a w_3 loading, especially for short spans. (See Charts I. and II. in previous article.) Since unequal spans cannot be avoided in transmission line work, the absolute pull along the line can be lessened materially. This is accomplished by reducing the tension for the shorter spans, *i.e.*, by altering the assumed basis of maximum loading at 0 degrees F. The ideal condition would be to have a +45 degrees temperature curve run vertically and the intersection points for all spans equidistant from this line (Chart III.). This would distribute the stress equally. From Chart III. we notice that at +30 degrees and a 600-ft. span, the tension is, say 3,250 lbs. By producing this +30 degree temperature curve vertically down and rectifying all curves below this point accordingly, we are able to distribute the stress more equally. The new basis to work from now is 3,250 lbs. at +30 degrees F. with no ice and no wind for spans ranging from 200 ft. to 500 ft. inclusively. The values for this new basis of w_1 loading (no ice and no wind) and 3,250 lbs. tension at +30 degrees F. will have to be substituted in equation 6.

w_1 is to be substituted for w_0, and 3,250 lbs. for P_0, and the temperature is to be based on +30° instead of 0° as before.

Table IX. shows these corrections and substituted in equation 6, we again solve for values of S_1 and P_1.

Table X. gives these new values for the sag and the tension, and plotted, we obtain the rectified curves for spans from 200 ft. to 500 ft., as shown on Chart IV.

It will be noticed that the tension for the 200-ft. span has been reduced to 4,880 lbs. at –30 degrees F.

If we attempt to couple this span with a 600-ft. span, we have a difference of 4,880 — 4,110 = 770 lbs. at —30° F. in favor of the short span and at 120° F., a difference of 2,465 — 1,545 = 920 lbs. in favor of the longest span, against a former difference of 2,290 lbs.

By proper substitutions we can figure what tension these spans would reach at 0° F. and maximum loading, and also at —30° F. and w_3 loading. The latter being the critical value. By substituting for this critical value in equation 6, we find a maximum tension of 5,520 lbs. for a 200-ft. span, which is less than the allowable tension of 5,900 lbs. In conclusion, it might be said that Chart IV. gives all necessary information to the engineer in the field for stringing wire according to the best engineering practice.

CEMENT AND PLASTER OF PARIS.

In 1912, Australia imported 2,603,792 cwt. (of 112 lbs.) of cement (Portland) to the value of £261,680. Of the quantity stated, Germany was the country of origin of 1,393,456 cwt., valued at £144,564, while Belgium contributed 269,760 cwt., valued at £25,879. Favorable freight rates and the quality of brands established on the market for many years were contributing factors to this trade. Australian manufacturers of cement have notified an increased output, but when present stocks of imported cement are exhausted there should be a market available for Canadian manufacturers, established near shipping port, to exploit.

In 1912, the imports of plaster of Paris, approximately, were 251,051 cwt., valued at £39,104, of which Germany contributed 116,659, valued at £17,184. This item is of particular interest to the manufacturers of plaster of Paris in Nova Scotia and New Brunswick, one brand of which is becoming favorably recognized in Australia. The plaster must be dead white to meet the requirements of the trade and any pink shade in the material will condemn it.—Canadian Trade and Commerce Report.

STANDARDS WITH REFERENCE TO SEWAGE TREATMENT.

By R. O. Wynne-Roberts,
Consulting Engineer, Regina.

IN the latest issue of the Public Health Journal there appears the paper on the above subject, which Mr. T. Aird Murray read at the Public Health Convention held in Regina in September, 1913. His paper was relegated to the tail end of the convention, and it was with regret that many found the time too limited for a full discussion.

Mr. Murray started by stating that engineers, when called upon to design sewage treatment work, will naturally "ask the Provincial authority to state what it expects and will insist upon with reference to the degree of purification and manner of sewage treatment." This would be an excellent procedure, but he further on states that it is "impossible to adopt any general standard of required degree of purity, and that each case under consideration requires separate adjustment with reference to local conditions and requirements." This places the engineer in an anomalous position, for he is left in doubt as to what may be required.

It should, however, be possible to give the engineer some indication as to what will be demanded to satisfy the provincial authorities as regards design, capacity and degrees of purification under certain specific conditions. Such requirements cannot, of course, be rigid or stereotyped, but should possess sufficient elasticity.

Mr. Murray next referred to the standards suggested by the Royal Commission on Sewage Disposal in their fifth report. These standards were revised in the eighth report and bear little resemblance to those quoted.

The revised standards are, that the effluent should not contain more than 3 parts of suspended matter per 100,000 parts, and with the suspended matter should not take up more than 2 parts of oxygen per 100,000 at 65° F. in 5 days. If the dilution is very low, then it is proposed to make the standard more stringent. If the dilution is from 150 to 300 volumes, the dissolved oxygen test may be omitted and 6 parts of suspended matter per 100,000 permitted. If the dilution is from 300 to 500 volumes, the suspended matter may be 15 parts per 100,000, and when the dilution is over 500 volumes crude sewage may be discharged into the stream after the coarser particles have been removed by detritus tanks and screens.

Mr. Murray appears to consider the British standards as inapplicable to Canadian conditions. It may be that they are less stringent than is desirable here, but that is only a question of degree of purification. These standards, however, afford the basis for others more or less stringent, and have been favorably considered by American authorities, for expert chemists, bacteriologists, sanitarians and engineers recognize that the purity of the effluent must be based upon the dissolved oxygen tests, the character of the bacteria, and the quantity and nature of the sediment contained in such effluent.

To ensure as uniform a quality of effluent as possible, it is necessary to conduct regular tests, and this entails the employment of chemists and bacteriologists as well as engineers, which would mean a heavy charge in the case of the smaller towns and cities. Even the employment of chemists and bacteriologists to conduct daily investigations will not obviate the discharge of unsatisfactory effluents, because sewage disposal plants are subject to disturbances, such as failure of pumping ma-

chinery, surcharging due to storms, fluctuation in flow of sewage, and to the frailty of human agencies in the management of such works.

The following extract from the report of the Royal Commission on Sewage Disposal was quoted by Mr. Murray: "That any authority taking water from such rivers for the purpose of water supply must be held to be aware of the risks to which the water is exposed, and that it should be regarded as part of the duty of that authority, systematically and thoroughly, to purify the water before distributing it to their customers." Bearing in mind the contingencies inherent to works of this kind, operated under such fluctuating and variable conditions, and by agencies which are inevitably more or less inconstant, the above advice is as reasonable in Canada as anywhere else. The risks are too great to allow of any town consuming water which is liable to contamination. The discovery of contamination is often subsequent to an outbreak of disease, and to depend on effectual purification of sewage effluent before its discharge into a stream is a risky procedure. Sewage treatment is one which varies hourly and daily. It is affected by climatic and meteorological influences, and by manufactural wastes. Its final oxidation by effectual dilution is affected by the fluctuating river flows, by varying velocities of the recipient stream, by the nature of the stream beds and surroundings, by seasons, and by the means adopted for dispersion and diffusion of the effluent.

Dr. Dunbar, when dealing with the pathogenicity of effluents, remarked that "in the case of rivers which serve as sources of water supply, attempts should be made to restrict the infection to a minimum." Whilst this advice is good, it introduces an interesting point, namely, the possibility of pathogenic germs surviving in sewage-polluted waters. Dr. Houston, the Director of Water Examination to the Metropolitan Water Board of London, England, has for many years been conducting a series of researches in this connection. His report may be consulted by anyone interested in this matter. It is the Ninth Research Report, published in April, 1913.

It is not necessary to enter into the details, but it may be stated that 28 samples of crude sewage-polluted waters—one set of which was purposely infected with typhoid bacilli and the other set was not inoculated—were examined according to the most approved method recognized by specialists. The average number of excremental bacteria, as judged by the bile-salt-agar test, was 1,155,040 per c.c. of sewage. Five thousand four hundred and eighty-five colonies recovered from each set of samples were studied, but not one of the colonies from the non-infected samples gave the characteristics of typhoid bacillus, but in the case of the infected samples, out of an average of 205 typhoid bacilli added per 0.01 c.c. of sewage, an average of 20 were afterwards isolated. "The positive result with one set and a negative result with the other justifies the conclusion that whatever number of typhoid bacilli were added to one set of samples, that number could not have been present in the other." Dr. Houston also states that the Thames water in its present condition does not, on the average, contain one single typhoid bacillus per 24 c.c. of water. Over 50 per cent. of the raw water samples contain B. Coli in 0.1 c.c., and less than 25 per cent. of the filtered water samples had B. Coli in 100 c.c.; so, generally speaking, he "concludes, on the basis of the test, that the purification process improves the water at least 1,000 times," and that it requires some imagination to conjecture the possibility of an ordinary consumer of London water imbibing an infective dose of typhoid malarial from this source, always assuming the absence of any accidental infection of the water between the works and the tap."

Like Worcester, Hereford, Shrewsbury and other towns in England, drawing water from contaminated streams, London depends on its supply of water from the Rivers Thames and Lea, both of which are observably contaminated with more or less sewage from a large number of towns, yet the typhoid fever death rate is only 3.3 per 100,000. The water is, of course, carefully stored and filtered before being distributed to the consumers.

The typhoid bacillus is rarely found in sewage, but, assuming a stray one does survive, Dr. Houston submits that it is difficult to believe that "the ingestion of a solitary typhoid bacillus would be likely to produce typhoid fever, even in a highly susceptible individual."

The above named authority, when discussing the incidence of typhoid fever in North America, which is usually attributed to the consumption of impure water, suggests that it may be due to accidental pollution by typhoid "carriers," of whom it is estimated there are about 3 or 4 per 1,000 inhabitants. Dr. Houston submits that the discharge of one person is potentially more dangerous than that of a community. As an instance of this the writer may refer to an epidemic of dysentery which occurred about eight years ago at Simon's Town, South Africa. When it was investigated it was discovered that a Kaffir suffering under that ailment had been employed on the watershed near the head works, and that on the next day there was a heavy rainfall, which evidently washed the filth into the water mains with the above result.

The writer may at a future date further discuss the incidence of typhoid fever from the engineer's point of view, but the foregoing will suffice to indicate that the problem of sewage treatment is one, the principal function of which is to safeguard the health of the public, as far as it is possible. But it is unwise to depend on such treatment to assure a pure water supply, even though thorough sterilization of the effluent is effected. In some parts it is difficult to secure an outfall which will not affect the water supply of a neighboring district. On the other hand, certain towns have contaminated streams or lakes as the most available source of water supply. The duty which devolves on the city authorities is to attain the highest possible efficiency in the treatment of sewage and in the purification of water. There nevertheless remains a duty on the provincial authorities to formulate a standard, and whilst some governmental officials consider it impossible to establish regulations as to the degrees of purification of sewage necessary under different conditions, it is becoming recognized that certain standards, subject to modifications to meet different requirements, can be formulated.

The Royal Commission on Sewage Disposal has published its proposed standards, which have already been quoted in the foregoing.

The authorities in Lancashire, Derbyshire and Yorkshire have their standards. Prof. Phelps submitted in connection with New York sewage disposal that the recipient waters should contain 70 per cent. of possible saturation of dissolved oxygen. Mr. Soper, chairman of the New York Sewerage Commission, considers that a definite standard of cleanness should be established as a guide for future operation. Dr. Winslow expressed an opinion that arbitrary standards are not feasible or desirable, but it is feasible to formulate standards as guiding principles, to be intelligently interpreted in the light of available knowledge in individual cases. He submits that the dissolved oxygen content of recipient waters

should not be less than 50 per cent saturation. There should be no effervescence, marked discoloration, decided turbidity, oily, sleek, floating, solid sewage material deposits of sludge or other conditions offensive to sight or smell.

With regard to the purification of polluted water, the International Joint Commission re Pollution of Lakes report that the number of B. Coli per 100 c.c. should be expressed as annual average, that the safe limit of loading water purification plants is exceeded when the annual number of B. Coli in the water delivered to the plant is higher than about 500 per 100 c.c., or when in 0.1 c.c. samples of water B. Coli is found over 50 per cent. of the time.

ELECTROLYTIC TREATMENT OF SEWAGE.

THE purification of sewage by electrolytic treatment has received considerable investigation during the past season by the Borough of Queens, New York City. A plant was installed at the Elmhurst disposal plant on March 26, 1914, for the purpose of observing the effect of the electrolytic and electro-chemical method devised and patented by Mr. C. E. Landreth, of Philadelphia. The process is being introduced by the Electro-Chemico Corporation of New York. It includes screening, passage through an electrolytic machine with addition of lime, and sedimentation for about half an hour. The sludge is dried by filter press. Both the tank effluent and the water extracted from the sludge are stated to be clear, almost devoid of bacteria, and non-putrescible. A report has recently been issued upon the operation and results obtained. From this report, written by Elmer W. Firth, C.E., Ph.D., Engineer of Maintenance, the following information is presented:

The sewage reaching this plant is very variable in composition. Cesspool wastes are permitted to be emptied from tank wagons into a sewer manhole adjacent to the receiving well. The capacity of these wagons varies from 400 to 1,040 gallons and on some days nearly a hundred loads of this strong sewage are added to the normal flow. This contribution will run from 10,000 to 60,000 or more gallons per day in a normal sewage flow of about 800,000 gallons. On the other hand, storm water and ground water render this sewage at times very dilute. The contribution of this cesspool waste has greatly increased the difficulty of treatment by the old methods.

History of Electrolytic Treatment of Sewage and Water.—It should be noted at the start that the present investigations were undertaken with full knowledge of the history of electrolytic appliances as they have heretofore been employed for sewage and water purification; their limitations and failures, the employment of correct principles and on the other hand the unscientific and ridiculous attachments which have from time to time been tried and then discarded as useless. All this, as recorded in the literature on the subject, has been sufficiently discouraging to serve as a warning against blinding enthusiasm for new methods. A brief review of previous efforts in this line will be helpful in comparing the process under consideration with its forerunners.

Electrolytic phenomena have been employed in two ways: First, by the immersion of electrodes in the sewage or water to be treated, and second, by the production of hypochlorites from salt solutions, to be subsequently added to the liquid under treatment.

William Webster, of England, appears to have been the first to utilize the principle of electrolysis in the purification of sewage about 1889, when it was tested on a small scale at Crossness and at other places. His patented process consisted in passing sewage through flumes in which iron or aluminum electrodes were immersed, and he called attention to the oxidizing and precipitating effect and suggested also the production of hypochlorite, which idea was developed three or four years later by Hermite, of France, and Woolfe, of America, in the manufacture of hypochlorite from common salt solution, or from sea water. These two similar ideas could not successfully compete with the cheaper production of hypochlorites on a larger scale and often as bi-products, and their processes appeared to have no advantage beyond the action of the disinfectant. The Woolfe "Electrozone" was used at Brewster, New York, and for a while at Danbury, Conn. The Hermite process was used at Ipswich, England, where the liquid hypochlorite was run into the main sewer. This was abandoned in 1905, after about ten years' operation, because the results obtained were not commensurate with the cost.

It is now recognized that where disinfection alone is desired, the expense is much reduced by applying the reagent as a finishing process after much of the organic matter has been removed from the sewage by sedimentation or filtration. It will, therefore, be perceived that these two processes showed no advance over the Webster process toward the complete purification of sewage.

Under the Harris patents, which were similar to the Webster process, experiments were made on Passaic River water about 1893, and the system was tested again at Louisville, Ky., by Mr. George W. Fuller, in 1896, and his report, "The Purification of the Ohio River Water at Louisville," refers to it as a complete failure. Harris had introduced magnets and a "sparking drum" for passing high-tension electric currents through the liquid, and notwithstanding Mr. Fuller's conclusion that they were absolutely useless, these features were again employed at Santa Monica, Cal., in 1908, but were finally abandoned, resulting in a return to the simple principles utilized by Webster. Alternate iron and aluminum electrodes were used at Santa Monica, spaced about ⅝ in. centre to centre, until it was found that the plates lasted only about three weeks. Later the electrodes used were all iron and they were bound on top with strips of copper in an attempt to lengthen the life of the plates, and it was claimed that the production of copper sulphate helped in the treatment. The Harris patents were later taken up by The Electro-Sanitation Company of Los Angles, which company secured new patents stripped of all useless devices that had been discarded after trial, and in this form the system was again installed at Oklahoma City in 1911.

Experiments were recently made at Toronto on electrolytic apparatus fashioned on the lines of the Oklahoma plant, and the degree of purification effected, according to the published analyses, is not calculated to engender confidence in the process.

All the processes thus far mentioned have relied on the consumption of the iron electrodes by the action of acid ions liberated from any electrolytes normally present in the water or sewage. These acid ions attacking the iron plates produce a certain amount of ferric hydrate, which serves as a coagulant, but in the presence of carbonic acid much of this is dissolved and passes on in solution as ferrous carbonate. Other soluble ferrous salts, such as iron chloride and iron sulphate formed by the attacking ions, constitute additional drains on the metallic iron. This accounts for the failure of the processes mentioned to effect a removal of the suspended matters in the

sewage proportionate with the great amount of iron wasted.

It was concluded from the Louisville experiments that atmospheric oxygen served to oxidize the ferrous to ferric salts, thus airing the formation of coagulants, but that atomic oxygen, produced electrolytically, tended to oxidize the iron plates, thus constituting a serious disadvantage in the waste of electric power and metallic iron, and further, that atomic or nascent oxygen did not result in the destruction of bacteria or organic matter. This was all doubtless true of the processes then under observation.

Electro-Chemical Process.—These deficiencies have all been fully met in the process employed at the Elmhurst plant by what will now appear a very simple conception, namely, the introduction of lime with the sewage or water under treatment. The lime solution is added in sufficient quantity to neutralize the free and half-combined acid present and render the liquid slightly alkaline to phenolphthalein. The lime solution serves three purposes: 1st—It prevents the waste of iron electrodes by neutralizing the attacking acid ions; 2nd—The calcium hydroxide, being readily ionized, liberates nascent oxygen from the hydroxyl, while the positive calcium at the cathode reunites with water to form calcium hydroxide again; 3rd—A bulky hydrated calcium carbonate is produced which with any ferric hydrate formed furnishes a remarkable coagulant which settles out in a few minutes, carrying with it most of the suspended matter.

The notable effect of the nascent oxygen in the destruction of organic matter and bacteria is evident from the analyses made.

The first bacteriological tests made on samples taken from the electrolytic machine and from the small sedimentation tank in unsterilized bottles and placed an hour later in the laboratory, showed amazing results in that only one plate out of twelve made with gelatine and agar developed two or three colonies, the rest remaining sterile. Fermentation tubes also showed no gas production in 48 hours, while gas was formed from sewage samples in full quantity in 24 hours and the sewage plates were overgrown with colonies. These results inspired a more careful and systematic study of the effects produced under the conditions adopted for operation.

It has been suggested by some of the engineers and scientists who have inspected this plant that lime alone would have a sterilizing effect, but Dr. Samuel Rideal has observed that "caustic lime used even to the extent of 60 to 70 grains per Imperial gallon (860 to 1,000 parts per million) of sewage is inefficient in sterilization," so that the bacteriacidal effect must be due to the ionization of the calcium hydroxide.

The suggestion has also been made that lime itself has sufficient coagulating effect, without the use of electrolysis, but observations made at the Columbus, Ohio, experimental station showed that 5.87 grains of lime and 5 grains of copperas, with 8 hours retention in tanks, removed only 52% of the suspended matter, and 11% of the dissolved volatile matter, and that the dissolved mineral matter was increased 3% and the bacteria 18%. The statement was also made that 8 hours was insufficient to effect complete coagulation with this amount of coagulant, or to allow for the sedimentation of the precipitant formed in this time. The lime in the Columbus experiments was then increased to 20 grains per gallon and a satisfactory clarification was obtained, but it is stated that a sedimentation period of at least 24 hours following the application was required to prevent the escape of hydrated coagulant from from the precipitation tank. According to a recent report by Sir M. Fitzmaurice, Chief Engineer of the London County Council, lime is held to be of little benefit as applied to London sewage.

In the face of this evidence a single observation of the wonderful coagulation and rapid sedimentation produced immediately with the use of lime in the Elmhurst electrolytic installation will convince the most skeptical of the unique advantage secured by electrolyzing this coagulating agent. The effect is to be ascribed to the hastening of chemical reactions under electric current.

No doubt the colloidal matters which may be assumed to be held in suspension by mutual repulsion of the microscopic particles, due to electric charges of similar polarity, owe their coagulation and precipitation, to a large extent, to neutralization of these charges by means of the current.

The conservation of the metallic iron of the electrodes is shown by the absence of color in sample of the effluent and by the small increase in the iron content, as shown by analysis. Inspection of the electrodes from time to time when the machine has been opened for the observation of visitors, showed no apparent corrosion, oxidation, or fouling, after 2½ months' use. The edges of the plates are still as sharp as when they were cut.

Other difficulties recorded both in the report on the Louisville experiments and in the application of electrolysis elsewhere, are: 1st—Polarization, and 2nd—The waste of iron electrodes even when the current is turned off, with the formation of deposits on the plates, which increase the power consumed in starting the process after a rest. The first of these difficulties is here overcome by the use of rotating elements in the form of paddles continuously operated between the electrodes. These serve several purposes, namely the prevention of polarization, the breaking up of solids in suspension, the cleaning of the plates, the mixing of the reagents produced electrolytically, and the bringing of all portions of the sewage into contact with the electrodes. It is hardly necessary to elaborate these suggestions, as the mechanical advantages will be apparent. It may, however, be well to explain that polarization is due to the tendency of ions to part with their electric charges more or less reluctantly, the positive ions attracted to the negative pole, for example, tend in some degree to remain positive and thus repel the following positive ions, which would otherwise be attracted. These are swept away by the revolving paddles. The breaking up of solids is important in view of the fact that sterilizing agents require some time to penetrate large masses or gelatinous membranes. The only other point which it seems necessary to note is that certain strata in the sewage flow tend to pass between the electrodes without coming in contact with them where the paddles are not used.

The second difficulty mentioned above, namely the waste of iron when the current is turned off, arises from reverse currents set up in the machine, which in the Elmhurst apparatus are taken care of by simply short-circuiting the iron electrodes with a zinc plate. The zinc being positive to iron attracts the current, thus saving the iron from decomposition and preventing the increased resistance observed in starting the electric current through the older devices.

Ten carbon electrodes which are placed in the Elmhurst machine at the point of entrance of the sewage, being electro-chemically passive, serve to utilize the common salt or other electrolytes normally present in the sew-

age, for the production of hypochlorite with its sterilizing effect. It will be noted that the lime solution used is introduced at a point above the carbon and just below the iron electrodes, for the reason that the electric current passes by way of the electrolyte which predominates, or which is more easily ionized, and the presence of the lime in the passive carbon electrodes would result in the dissociation of calcium hydroxide, rather than the sodium chloride, and no sodium hypochlorite would be liberated.

Description of Electro-Chemical Apparatus.—In the old process the sewage on entering the receiving well at the Elmhurst plant passes through a perforated metal screen with ⅝ in. circular openings, and is pumped to the level of the sedimentation tanks, from which it flows by gravity to sand filter beds. There are four of these old sedimentation tanks used in series, each holding about 65,000 gallons, and enclosed under the roof of the building.

In preparing for the tests on the new electrolytic process, the apparatus was placed on a temporary platform built over one end of the first tank in the old series above mentioned. This platform has a floor area of 18 x 24 ft., which provides sufficient room for a 2-in. centrifugal pump and motor, the electrolytic machine, lime solution tank, effluent sedimentation tank, platform scale and laboratory table. The pump was required only for the purpose of lifting the sewage treated to the higher level above the flow of the old tanks. A ⅜-in. perforated screen is used on the suction line of this pump. The electrolytic machine used is erected vertically, the sewage flowing through the bottom to top, the electrodes being entirely enclosed. It stands 7 ft. 3 in. high from the floor to its outlet pipe flange and is 24 in. x 18 in. in cross-section. The cypress frame enclosing the electrodes is 4 ft. 10 in. high, sets on a cast iron base, which holds also the motor-generator set, is capped with the outlet casting which is bolted through to the base by outside bolts at the four corners. The electrodes are set horizontally one above the other. At the bottom of the electrolytic machine one bank of 10 carbon plates, or electrodes, are placed and connected in series, and above this are four banks, each consisting of 12 iron electrodes. The alternate iron electrodes are connected in groups of three and these groups are then connected in series. The one bank of carbon plates is parallel with the whole set of iron electrodes, so that 9/10 of the current is taken by the carbon and 1/10 by the iron electrodes. The iron plates are connected so as to be automatically short-circuited to a zinc plate in the top when the operating current is shut off. A volt meter and an ammeter are attached to the front of the machine. The motor of the generator set furnishing direct current for the electrodes also rotates two ¾-in. vertical square steel shafts connected by gearing to the motor shaft. These vertical shafts carry paddles which operate between the electrodes continuously. The shafts are made in sections just long enough to pass through a single bank of electrodes and the sections are keyed together in the spaces between each bank. This arrangement supplies two paddles in each space between the electrodes and they are rotated in opposite directions, one slightly in advance of the other, with high mechanical efficiency since the water pressure generated by one aids in driving the other. The paddles are made of material which is non-absorbent, non-conducting and very durable. In this machine they are 9 in. long, ¼ in. thick and 2¼ in wide at the centre, tapering to 1⅛ in. at each end, while the shaft opening at the centre is a ¾ in. square.

The iron electrodes are made of a certain grade of low carbon steel and are 10 in. x 16 in. x 3/16 in. thick and spaced ⅜ in. apart. An opening is left at one end of the lower plate in each bank for the entrance of the sewage or water, which then is divided by the plates into thin films as it passes on to the next bank of electrodes. A space of 3 inches between each bank or section of electrodes facilitates the connection of the paddle shaft sections as they are inserted with each tank of plates when the machine is erected.

Lime Tank.—The lime solution tank used is 3 ft. x 5 ft. and 3 ft. deep, holding about 336 gallons. Lime solution is introduced into the electrolytic machine just above the carbon electrodes and mixes with the sewage as it passes from the carbon to the iron plates. In this instance a small plunger pump electrically driven was used to inject the lime, as there was not sufficient head room to secure a gravity flow into the machine. From the electrolytic machine the sewage flows through a weir box to provide means of measuring the quantity treated. This box is 23 in. x 37 in. x 17 in. deep, with a 3-in. pipe outlet into the sedimentation tank.

Sedimentation Tank.—A small sedimentation tank is provided to take the flow from the electrolytic machine. Its outside dimensions are 11.5 ft. x 7 ft. x 5 ft. and was built as a two-story tank with a false bottom sloping from a line 2 ft. below the top on one side, down to the front bottom edge, but as septic action plays no part in this process, the effluent is permitted to pass through the sedimentation slot and emerge from the 6-in. space between the side of the upper compartment and the outside wall of the tank. This space is usually provided for the escape of septic gases in biological processes when it would be filled with decomposing sewage. Notwithstanding the unsuitableness of the design, this tank has served as well as any, inasmuch as any form of tank properly baffled and with convenient means for removing the sludge, is all that is needed. Its effective capacity is only 1,550 gallons, which, at the rate of 25,000 gallons per day, gives a theoretical retention period of ½ hour. However, tests have shown that the clarified effluent leaves this tank in from 10 minutes to 1 hour. This was conveniently tested by the introduction of phenolphthalein, which holds its pink color in the slightly alkaline effluent throughout the flow through the tank. The strongest traces of color usually emerge in about ½ hour.

The time of flow through the electrolytic machine when 25,000 gallons per day were being treated, averaged about 2 minutes, though the first traces of color showed in 1 minute and all color of the indicator used had disappeared in 3 or 4 minutes.

The weir box was calibrated by means of a scale fastened to the inside. The flow was measured by weighing the effluent on a platform scale, and a curve was plotted to indicate the number of gallons treated per day for each reading on the scale in the weir box.

The quantity of sewage treated was generally held at 25,000 gallons per day to suit the capacity of the lime tank and the small sedimentation tank and also to maintain uniform character in the effluent, which, after settling in the small tank, was run into the large plant tank below, and there retained for observation.

Amount of Lime Required.—The amount of lime used will vary in each case with the normal free and half-combined carbonic acid contained in the sewage. The softer the water of the public supply, the less the amount of lime required for purification. The lime used at Elmhurst averages about 1,200 lbs. per 1,000,000 gal.

As shown by the analyses, the hardness of the Elmhurst water supply is 102 p.p.m., total hardness, and the lime necessary to overcome this is 496 lbs. per 1,000,000 gal. of sewage. Analysis of the effluent shows that the hardness is reduced 50%.

In treating the sewage of the Borough of Manhattan only 180 lbs. of lime per 1,000,000 gal. would be required to overcome hardness, since the total hardness of Croton water is only 40 p.p.m. This would indicate that only 941 lbs. of lime would have to be used per 1,000,000 gal. in the electro-chemical treatment of sewage in Manhattan.

Power Used.—The electric power supplied to this plant is alternating current, 2-phase, 220 volts, 60 cycle. The current used for electrolysis on a flow of 25,000 of sewage daily is 18 to 20 amperes, with a pressure of 7½ volts, or a power consumption of 135 to 150 watts, which is about 1/5 h.p. The carbon electrodes take about 9/10 of the current, the balance going to the iron electrodes; hence out of 20 amperes 18 go to the carbon and the remaining 2 amperes are seriesed 8 times on the iron plates, giving an efficiency of 16 amperes on the iron. Estimating the power required per million gallons from the above figures, and remembering that with the increase of plate area in larger machines, the voltage required to put through a given amperage is proportionately reduced, about 6 kw. should be sufficient to effect the high degree of purification obtained in these tests.

Where an electrolytic machine designed to treat 1,000,000 gallons is installed, and a similar reserve unit is added, the utilization of both machines simultaneously for the million-gallon flow should cut the voltage required in half, since the plate area is doubled and the amperage remains the same. This would also halve the cost of power, which is the product of the voltage by the amperage.

Improved Electro-Chemical Machine for Sewage Treatment.—The electrolytic machine tested here was designed primarily for water purification. An improved type for sewage purification is now being built. It is designed to be installed horizontally, with the electrodes in a vertical plane and set longitudinally to secure the advantage of having the grit drop to a bottom trough. This also minimizes wear on the electrodes due to the grinding of grit by the rotating paddles, which in the new arrangement will, of course, turn in a vertical plane. In the vertical machine tested at Elmhurst this wear, however, has been hardly appreciable, notwithstanding the surface of the electrodes underneath the paddles are more subjected to it. The large machines are about 20 ft. long and 3 ft. square. As is usual with most mechanical and electrical devices, higher efficiency may reasonably be expected with increasing size.

Effects produced.—The effluent from the electrolytic machine shows immediate coagulation and when taken in a glass and held to the light the flocculent precipitate is seen to increase rapidly in bulk and starts to settle immediately. The liquid between the coagulated particles at once appears clear. Grease is rapidly saponified by the lime under the hastening action of the electric current and precipitates out as lime soap. This effect can be illustrated by the simple experiment of adding lime to a soap solution and holding two carbon electrodes in it for a moment.

Grease is one of the most disturbing elements in the purification of sewage by biological processes, on account of its tendency to clog bacterial filters and dosing devices, and the difficulty with which it is decomposed and mineralized by bacteria. Electrolytic treatment is well suited to handle sewage of this character.

Nitrogenous organic matter in the sewage becomes highly oxidized in this process, and this, together with the dissolved oxygen produced, yields an effluent of very high stability and as it leaves the small sedimentation tank after about ½ hour's retention, it is clear, colorless and without odor. The removal of bacteria is close to 100%. Disease-producing germs and allied species, outside of the body, are destroyed more readily than the ordinary bacteria of decomposition and hence if a few bacteria survive electrolytic treatment, they will not be pathogenic germs. This is borne out by observations on cultures made to identify this class of bacteria.

Storage of the Effluent for Observation.—From the small settling tank the clear effluent was run into the large concrete sedimentation tank, over which the electrolytic apparatus was erected. This tank has a capacity of about 67,000 gallons and is one of the four regular sedimentation tanks built with the Elmhurst plant. Chemical and bacterial observations made from time to time on the liquid stored in this tank showed some very interesting results. The bacterial content remained very low and the fixation of nitrogen, as shown by the increase in the nitrites and nitrates on standing, is remarkable, notwithstanding the fact that the tank is open to contamination from the air and by birds which nested in the rafters of the roof. This tank was kept full for 66 days. When emptied, a light deposit, about ¼ inch thick, was found at the bottom. This was light colored and inoffensive and was composed largely of calcium carbonate. The clear appearance of the water in this tank made interesting contrast to the dark septic sewage in the adjacent tank, with its deposited sludge continually forced to the surface in large masses by the rising gases of decomposition.

Sludge.—The flocculent precipitate in the machine effluent after sedimentation in the small tank was drawn from the bottom of this tank through 2-inch outlet pipes and forced into a filter press under about 25 pounds pressure by means of a small water-feed pump. At this pressure about 20 pounds of liquid sludge, containing about 95% moisture, could be dehydrated per hour, per square foot of filter area, based on the operation of a large press. The percentage of moisture remaining was from 55 to 60%. The filtrate from the sludge is quite odorless, colorless and has sufficient available oxygen to remain nonputrescible. The sludge has no odor, except possibly a very slight suggestion of ammonia.

The extraction of this readily settling sludge from the electrolytic machine effluent, by a process other than sedimentation in tanks, is now being considered, but on account of the short period of sedimentation required the elimination of a small tank area would be important only under exceptional conditions.

Cost.—Without including pumpage, the necessity of which would have to be determined at each point of treatment, according to topography, the cost of electricity for electrolysis at the rate of six kilowatts per million gallons at a cost of 3c. per kilowatt hour is 6 x 24 x .03 = $4.32

Lime 941 lbs. x .003 = $2.83

$7.15

Disastrous fires at the docks along the Seattle waterfront have led to an ordinance providing that all docks constructed hereafter shall be provided with fire walls spaced not further apart than 500 ft. on centres and fire stops not more than 100 ft. apart. These provisions are not required in structures fully equipped with automatic sprinklers.

Editorial

THE WORDING OF SPECIFICATIONS.

One of the most frequent causes of trouble between owners, engineers and contractors is the inability of some engineers to express their requirements clearly, concisely and in plain, unequivocal English, so that all concerned may read and know what their specifications mean and call for. Most of this trouble can be ascribed to the practice of copying specification provisions from some other person's work or from some ancient specifications with no regard or consideration as to whether the class of materials is the present market classification or whether even obtainable except at an exorbitant price. Such specifications usually contain ambiguous phrases which have been rightly named "club" or "big stick" clauses, unfair to all parties, and which create the impression that the engineer himself does not know what he wants, and that he expects to cover up his deficiency by other common phrases such as "the decision of the architect as to the true construction and meaning of the drawings and specifications shall be final"; "that all work and materials must be to the entire satisfaction of the engineer"; "that all materials must be of the best quality"; "that all work must be done in the best manner as the engineer shall direct," etc. Nor do these expressions always accomplish the expected result. Some examples that well illustrate this were enumerated by Wm. L. Bowman, C.E., LL.B., in a paper entitled "The Engineer and the Law," read before the Harvard Engineering Society, of New York. One instance he cites was where a contract for a heating plant provided for a "complete and perfect job, even though every item required to make it such is not specially noted in the drawings or these specifications"; also that the contractor "shall furnish all labor, tools, and appliances necessary to complete his work according to these specifications, and shall perform his work in a true workmanlike manner in every particular, and thus provide the building with a durable and mechanically perfect system"; it was held that the contractor was not required to improve upon the plans in order to make a mechanically perfect system.

Another example given by Mr. Bowman was where a contract required the construction of a cellar according to specifications, it was held that an additional requirement that "the whole to be perfectly watertight and guaranteed" only bound the contractor so far as his own work was concerned, and that he was not held to guarantee that the plans would produce a watertight job. In another instance, where a tin roof of the "best quality" was called for, the trial justice in charging the jury held that such a requirement was satisfied when the roof as finished "was equal to the standard contemplated by the contract." In another contract a reservoir was required to be built according to definite plans and specifications, and the contract further provided that "the work contemplated . . . is the construction of a watertight reservoir," and it was held that that did not impose upon the contractors the responsibility of making the reservoir watertight, because consideration of the entire terms of the contract showed that they had no discretion as to the method or means of doing the work.

These numerous examples are given because of the tendency on the part of some architects and engineers to reject work under such circumstances, involving all concerned in expensive and needless litigation, and opening themselves to severe and sometimes well-merited criticism.

CO-OPERATION BETWEEN SCIENCE AND BUSINESS.

Professor Ed. D. Jones, in his new book on business administration, makes some interesting allusions to the fruitful co-operation of men of widely differing talents, in business. He shows clearly how industry and science agree in making extensive use of that simple form of co-operation, commonly known as division of labor, by which men of unlike genius are united in the same enterprise for the accomplishment of different functions. He turns first to pure science of modern times and displays a striking instance, in the life history of two noted men, of the benefits of individual co-operation. Tycho Brahe, the leading astronomer of the latter half of the sixteenth century, was a nobleman of proud spirit and, by reason of a certain dramatic talent which attracted attention, able to secure from his royal patrons large grants for astronomical apparatus. He was an expert instrument maker, and an accurate observer. His life was spent largely in compiling tables of observations of planetary movements. Kepler, who came under his patronage, and who worked with him for many years, was a poor observer, suffering from defective eyesight. He was awkward in his movements and possessed little mechanical ability. He was, however, a good mathematician, and he possessed the rare ability to become enthusiastic over statistical calculations. The five laws of planetary motion which Kepler discovered, and the Rudolphine tables which he completed, are monuments to a splendid and devoted co-operation between two geniuses of entirely different endowments.

As for applied science, the writer reverts to the more familiar case of Isaac Watt and Matthew Boulton. Watt has described himself in the following words: "I am not enterprising. I would rather face a loaded cannon than settle an account or make a bargain; in short, I find myself out of my sphere when I have anything to do with mankind." Boulton was a man of affairs, full of energy and common sense, and possessed of property. He is remembered because he was able to perceive and respect the talent of a man entirely different from himself, and because he tenderly encouraged and courageously defended that genius through manifold attacks and disappointments, to the lasting benefit of the world.

Professor Jones treats the subject in a manner that permits of but brief mention here. One observation of his will bear frequent repetition, however. It is this: "There are even enough men of wealth ready to enter into an arm's-length alliance with science and education, by means of a cold bequest. But there is a waiting opportunity for men of affairs to go into living, daily partnership with the arts and sciences, by entering into close personal relationships with men who need help of a natural administrator to make their contribution to progress. A good many captains of industry might weave their names firmly into the fabric of history, as did Boulton, by aiding some delicate flower of genius with energetic counsel and a wise corrective influence.

PERMEABILITY OF GRAVEL CONCRETE.

THE following is a summary of tests that have been under way at the Engineering Experiment Station, University of Wisconsin. They were recently described in a paper read by Prof. M. O. Withey, before the Western Society of Engineers.

1. None of the concretes tested were absolutely watertight if we consider continuous flow into the specimen as proof of permeability, but the majority of the mixes (varying from 1 : 1 to 1 : 3 : 6) were so impervious that no visible evidence of flow appeared. For most purposes such mixes can be considered watertight.

2. The visibility of dampness on the bottom of the specimens increased with the humidity of the air and the non-homogeneity of the concrete. The minimum rate of flow for which leakage was indicated was 0.00011 gal. per sq. ft. per hr.

3. In tests of nearly all of the properly made mixes of 1 :7 proportions, or richer, the rate of flow for a 50-hr. period was less than 0.0001 gal. per sq. ft. per hr. under a pressure of 40 lb. per sq. in.

4. Through increasing the fineness of the cement a reduction in the rate of flow and a considerable increase in the strength of a 1 : 9 mix were secured.

5. By grading the sand and gravel in accordance with Fuller's curve it was possible to obtain practically watertight concrete of 1 : 9 proportions under pressures less than 40 lb. per sq. in. To secure such results, however, requires great care and careful supervision in mixing, in determining the proper consistency, in placing, and in curing the concrete.

6. In the proportioning of such materials as these, volumetric analysis coupled with a determination of the density and air voids yields very valuable information concerning the best proportions of sand and gravel for a given proportion of cement. If proportions must be selected arbitrarily a 1 : 1½ : 3 mix, by volume, is very impervious.

7. The use of the proper amount of water necessary to produce a medium or mushy consistency is one of the most important conditions in securing impervious concrete, especially when lean mixtures are used. Dry mixtures cannot be sufficiently compacted in the molds and are more difficult to cure properly than the mushy mixtures. Although the use of a wet consistency does not materially affect the imperviousness of very rich mixes, such as 1 : 1½ : 3, it greatly increases the flow through a lean mix.

8. For lean mixes made from damp sand it seems advisable to mix longer than is now common practice. These tests would indicate that for a mixer running at 30 r.p.m., a period of one and one-half to two minutes is required to secure thorough mixing of a 1 : 9 concrete. For a rich 1 : 1½ : 3 mix a one-minute period appears to be sufficient. The method of mixing in which water is first admitted to the mixer is to be condemned. A preliminary period of dry mixing lasting from 15 to 30 sec. seems desirable.

9. No stage or process in the making of impervious concrete is of more importance than curing. The results of these tests clearly demonstrate that premature drying destroys the imperviousness of 1 : 9 mixes, seriously impairs that of the 1 : 2 : 4 mixes and somewhat diminishes that of the 1 : 1½ : 3 mixes. For thin sections, not over six or eight inches thick, the curing conditions should be such that a lean concrete will be kept damp for a period of one month and a rich concrete for at least two weeks. Even after a month of proper curing, complete desiccation of a lean mix composed of these materials produces an increase in permeability, but the effect on a rich mix is not marked.

10. In these tests the imperviousness of the concrete increased rapidly with the age of the specimens for the first month; thereafter the change was not marked.

11. From the tests thus far made it seems probable that the permeability of lean concrete in a direction normal to the pouring is greater than in the direction of pouring.

USE OF CONCRETE IN WATERWORKS CONSTRUCTION.*

THE author does not pretend to advance any new theories, but rather endeavors to present in convenient form the general principles involved in the use of concrete in such structures as may be employed in connection with waterworks. There is no recognized standard test or specifications now in use for concrete. There has not as yet been developed a set of standard tests or specifications, the use of which will in cases guarantee entirely satisfactory finished work. That the cement and aggregate stand the laboratory tests is no guarantee that the workmanship will give the best of results.

Neither sharpness nor excessive cleanliness in the sand is worth seeking after if it involves much expense. Tests have shown conclusively that sand with rounded grains makes quite as strong a mortar, other things being equal, as does sand with angular grains. Comparative sand tests of cement-sand mortar should be based on compressive strength values instead of tensile strength values. The strength of all sand mortars is affected by the amount of water used over that required for normal consistencies. The more water used the greater will be the loss in strength at early periods. A fine sand takes much more water to produce a certain consistency of mortar when mixed with cement than does a coarse sand. A fine sand makes a weaker mortar than a coarse, because of the lower density. The only substitute for natural sand for concrete that need be considered is pulverized stone, either dust and fine screenings produce in crushing rock or an artificial sand made by reducing suitable rocks to powder. The danger of using stone dust is failure to secure the proper balance of large size grains. The coarseness as well as the fineness of a good concrete sand is limited. The best sands will show not more thon 40 per cent. retained on a No. 10 sieve, and not more than 5 per cent. passing a No. 80 sieve.

Upon large or important structures it pays from an economic standpoint to make very careful studies of the materials of the aggregates and their relative proportions. W. B. Fuller has shown that by changing the ordinary mixture of watertight concrete, which is about 1 :2½ :4½, and which requires 1.37 barrels of cement per cubic yard of concrete, by carefully grading the materials by methods of mechanical analyses he was able to obtain watertight work with a mixture of about 1 :3 :7, thus using 1.01 barrels of cement per cubic yard of concrete. This saving of 0.36 barrel is equivalent, with Portland cement at $1.60 a barrel, to 58 cents per cubic yard of concrete.

A better and more uniform concrete can be made with a good machine mixer than by hand. A plastic con-

* Abstract of a paper by Edgar B. Kay before American Water Works Association.

crete of jelly-like consistency always produces stronger concrete than a wet mix and is preferred where conditions will admit of its use. It is absolutely necessary, however, in reinforced concrete to employ a consistency sufficiently wet to flow around the steel and into the corners of the forms and in rubble concrete, to flow around the large stones.

Concrete should never be placed in running water.

It is almost impossible to satisfactorily plaster a face of hardened concrete.

A wall of concrete may be rendered watertight in various ways:

1. By accurately grading and proportioning the aggregates and the cement. The proportions employed to resist the percolation of water usually range from 1 : 1 : 2 to 1 : 2½ : 4½, the most common mixture being 1 : 2 : 4 or 1 : 2½ : 4½. With accurate grading by scientific methods, watertight work may be obtained. For maximum watertightness, a mortar or concrete may require a slightly larger proportion of fine grains in the sand than for maximum density or strength. In general it may be stated that in monolithic construction a wet mixture, a rich concrete and an aggregate proportioned to secure great density will in the majority of cases give the desired results. It is impossible to specify definite thicknesses of concrete to prevent percolation under different heads of water, because of variations in proportions and methods of laying.

2. By special treatment of the surface of the concrete. Various methods have been employed, such as plastering the surface of concrete with rich Portland cement mortar in proportions 1 : 1 or 1 : 1½. Watertightness may also be secured by the use of a granolithic finish; by troweling the surface so as to produce a hard finish. Layers of waterproof paper or felt cemented with asphalt or bitumen or tar are extensively used, and sometimes asphalt alone. A mixture of alum and lye has also been used.

3. A waterproof concrete can be prepared by the application of fluates. The operation, however, requires a great deal of time and labor. By the application of an 8 per cent. solution of potash soap, instead of water, in mixing, the concrete can be rendered waterproof, so as to fulfil all requirements as to permeability of water.

The first method suggested is unquestionably the best to secure permanent watertightness, and the writer is not in favor of using waterproofing ingredients or of making surface applications except in cases where such may be required by reason of imperfections in the original concrete.

NEW BUILDING FOR THE HYDRO-ELECTRIC POWER COMMISSION.

A new office building, to cost approximately $200,000 is to be erected by the Hydro-Electric Power Commission of Ontario on a newly-purchased site on University Avenue. The building will be 6 stories in height, with white stone frontage and will be constructed of brick. Its floor dimensions are to be 63 x 83 ft. The whole of the building will be used by the Commission. Contracts for the exterior work were let last week to Messrs. Witchall and Sons, Toronto.

Agents of the Grand Trunk Pacific are taking measures to get Belgian settlers for the territory opened by the company's lines in western Canada. It is expected that the European war will result in a rush of settlers to Canada. Belgian farmers are very thrifty people. It is hoped to settle a large tract in the Stuart River district.

Coast to Coast

St. Andrews, N.B.—Plans for the rebuilding of the C.P.R. Algonquin Hotel, burned last April, have been prepared by Barrott, Blackader and Webster, architects, Montreal. A reinforced concrete structure is contemplated.

Sault Ste. Marie, Ont.—The third lock of the St. Mary's Falls canal was formally opened to traffic last week. It is 1250 ft. long, 80 ft. wide and 23 ft. deep. Its construction began in 1908, and has cost $6,250,000. It is rated the longest lock of its kind in the world.

St. Vital, Man.—The Manitoba Engineering and Construction Company, of Winnipeg, were awarded, last September, the contract for the construction of a 12-inch cast-iron water main to extend from the pump-house at this point to a reservoir in the National Transcontinental Railway yard at Transcona. This is being proceeded with, and is giving employment to quite a number of laborers. The estimated cost of the line is $87,000.

Brandon, Man.—Last week Mr. J. G. G. Sullivan, chief engineer of western lines for the C.P.R., made the announcement that 350 miles of double-tracking had been completed during the season between Brandon and the Pacific coast. Prior to this year the road had been double-tracked from this point to Fort William, which makes a distance of 909 miles completed to date. The entire distance between Fort William and Vancouver is 1908 miles. It is expected that the line of the C.P.R. between Swift Current and Bassano will be completed in a few days

Montreal, Que.—As announced in another department of this journal, the Grand Trunk Pacific Railway is going ahead with the construction of terminals in British Columbia. Contracts to the value of $300,000 at the four divisional points, viz., Prince George, Smithers, Pacific, and Endako, have recently been let. They include the construction of roundhouses, machine shops, and other railway facilities, and will require the services of large numbers of mechanics and laborers during the winter months. It is to be noted that large oil storage buildings are included, indicating that the company may have under consideration the use of oil-burning locomotives on its fast transcontinental service.

Montreal, Que.—No sooner had the contractors placed the roof on a large extension to the Ross Rifle factory than work was commenced on a second extension, which will double the size of the present factory, and more than double its capacity. The output of the enlarged factory will be at least 500 rifles per day. The contractors for the new structure, the C. E. Deakin Co., of Montreal, have been urged to rush the work, and the concrete foundations are already being placed. The building, which will be of brick construction, is to be handed over on December 1st, ready for the installation of machinery. It is also understood that the Quebec Railway, Light and Power Company has signed up a contract with the Ross factory for a large block of additional power. The machinery and equipment for the extensions are on the way from England.

St. John, N.B.—Several large steel bridges are now under construction in this Province. The spandral arch bridge at St. John, which bridges the Reversing Falls, and which will be utilized for street car and general traffic, is well advanced, and the remaining work will be completed in time for use next spring. The new steel bridge, which the provincial government is constructing at Grand Falls, is almost completed, and in a few days the finishing touches will have been made to the magnificent new bridge

which crosses the Miramichi river at Newcastle. In addition to these splendid structures two large steel bridges for the use of the Valley Railway are in contemplation. The C.P.R. also has under consideration the building of a new cantilever bridge, of a somewhat different type from that now used by the railway, at the Falls, St. John.

PERSONAL.

J. J. McNIVEN, B.Sc., of Vancouver, has been appointed assistant inspector of gas and electricity in that city.

JOHN T. MATTHEWS, of St. John, N.B., has been appointed inspector of boilers and machinery and of hulls and steamboat equipment at Edmonton, Alta.

R. A. ROSS, consulting engineer, Montreal, has been retained by the city of Peterborough, Ontario, as its representative in the settlement of the taking-over of the plant of the Peterborough Light and Power Company by the city.

T. R. DEACON, C.E., whose second term as Mayor of the city of Winnipeg is drawing to a close, has announced that he will not seek re-election to the office. Mayor Deacon's work in connection with the Greater Winnipeg Water District has been of such a nature as will for all time associate his name with the supply of good water to the city of Winnipeg. It was to further the scheme that he permitted himself to be chosen as head of the civic administrative board, and the present extensive construction work on the 95-mile aqueduct bespeaks the fruits of his great service to the city.

H. S. VAN SCOYOC, A.M. Am. Soc. C.E., has been appointed chief engineer of the Toronto-Hamilton highway, on which work is to start at once. Mr. Van Scoyoc has been inspecting engineer of the Canada Cement Co., Limited, at Montreal, for the past few years, and is thoroughly familiar with the construction of concrete roads. The Toronto-Hamilton Highway Commissioners chose Mr. Van Scoyoc in order to make the Canada Cement Co. more definitely responsible for the success of the road than the company would be if the engineer in charge were not practically one of its own men.

OBITUARY.

The death has been announced of Mr. E. R. BABINGTON, a well-known architect of Toronto. The deceased started his profession in 1874, and, after twenty-three years of active professional work, he became an instructor in the Toronto Technical School, which position he held until forced by ill-health to resign.

INSPECTION OF NEW WELLAND SHIP CANAL.

As intimated in last issue, a tour of inspection was made over the sections of the new Welland ship canal now under construction, by members of the Toronto branch of the Canadian Society of Civil Engineers, and of the University of Toronto Engineering Society, on Saturday, October 31st. Several hundred took advantage of the opportunity afforded them by Mr. J. L. Weller, chief engineer of the Canal, to examine closely the enormous equipment and methods, somewhat unusual to Canadian construction, that were to be seen on Sections 1, 2 and 3.

The party was divided into groups, each looked after by several members of the engineering staff of the Canal. Beginning at Thorold, the various features of the work, outlined in the leading article of this issue, were examined, every development of interest between that town and the harbor at Port Weller receiving the attention of the closely interested engineers. Luncheon was served at one of the construction camps; electric cars, drawn by one of the locomotives, conveyed the party along the department's construction railway. At the close of the day a dinner was held in St. Catharines, the party returning to Toronto by special train.

EDMONTON BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Edmonton Branch of the Canadian Society of Civil Engineers held their regular meeting on Oct. 22nd. An informal dinner was served to about forty-five guests. Following the dinner, the gathering was addressed by A. M. Calderon, F.R.A.I.C., and J. L. Cote, M.P.P., on the Military Engineers' Corps, which is now established in the city. Several military engineers who were present also gave short addresses on various aspects of military engineering. The members of the Branch, who strongly favored the movement regarding the formation of a local corps of military engineers, unanimously passed the following resolution: "Whereas there are a large number of qualified engineers having headquarters at Edmonton who are desirous of putting their scientific training and practical experience at the service of the Empire; be it resolved that the Secretary of the Branch be instructed to communicate with the District Officer commanding this military district, urging upon the Militia Department the desirability of authorizing an engineering unit in Edmonton."

The chair was occupied during the evening by Professor Edwards, of the University of Alberta. Mr. L. B. Elliot is the secretary of the Branch.

COMING MEETINGS.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

WASHINGTON STATE GOOD ROADS ASSOCIATION.—Convention to be held at Spokane, Wash., November 18th, 19th, and 20th. Secretary, M. D. Lechey, Alaska Building, Seattle, Wash.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

EIGHTH CHICAGO CEMENT SHOW.—To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.

AMERICAN WATERWORKS ASSOCIATION. — The 35th annual convention, to be held in Cincinnati, Ohio, May 10th to 14th, 1915. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—Annual meeting to be held at the Iowa State College, Ames, Iowa, June 22nd to 25th, 1915. Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Volume 27. Toronto, November 12, 1914

Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

THE FILING OF ENGINEERING LITERATURE

THE DEWEY DECIMAL SYSTEM OF CLASSIFICATION IN ENGINEERING AND ITS EXTENSION TO COVER MUNICIPAL ENGINEERING.

By R. DeL. FRENCH, Assoc. Mem. Can. Soc. C.E.; Assoc. Mem. Am. Soc. C.E.
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IN every engineering office there are catalogues, photographs, pamphlets, drawings, books, clippings, etc., which, to be of the greatest use, must be filed so as to be kept in order and yet to be easily accessible. In addition to such matter, the engineer should keep a list of references to articles in the engineering periodicals and in the proceedings of the engineering societies which are of particular interest to him.

The actual filing of such matter is probably best accomplished by the use of the familiar vertical system, and the index to the contents of the files is most conveniently kept on standard cards, 3 in. x 5 in. in size. Many systems of indexing have been devised which are more or less satisfactory. Any alphabetical system is open to the objection that it requires copious cross-indexing to make it of much value. The numerical systems are, therefore, the more popular, and justly so.

The Dewey decimal system, developed by Melvil Dewey, formerly director of the New York State Library, is probably the best of the numerical systems. It is in great favor with library workers and is used in the majority of the public libraries of the United States and Canada.

The following explanation of this system is based on that given in "An Extension of the Dewey Decimal System of Classification Applied to the Engineering Industries" by Breckenridge and Goodenough, of the Engineering Experiment Station of the University of Illinois at Urbana. This bulletin, as well as one giving a similar extension of the system to cover architecture and building, may be obtained from the Director of the station for a low price.

The essential characteristic of the Dewey system is its method of division and subdivision. The entire field

628.183(02)
H

Hazen, Allen.

Filtration of Public Water Supplies. 321+xii pp. Illust. John Wiley & Sons, New York, 3rd edition, 1903.

(Author Card)

628.183(02)
H

Filtration of Public Water Supplies.

Allen Hazen.

(Subject Card "a")

628.183(02)
H

Public Water Supplies, Filtration of.

Allen Hazen.

(Subject Card "b")

628.183(02)
H

Water Supplies, Filtration of Public.

Allen Hazen.

(Subject Card "c")

Fig. 1.

of knowledge is divided into nine chief classes numbered by the digits from 1 to 9. A tenth class for matter too general in nature to fall in any one of the other nine is numbered 0. The following are the primary classes:

0 General works.	5 Natural sciences.
1 Philosophy.	6 Useful arts.
2 Religion.	7 Fine arts.
3 Sociology.	8 Literature.
4 Philology.	9 History.

Each of these classes is again divided into nine divisions with a tenth for general matter, and each division is separated into nine sections. The sections are again subdivided, and the process may be carried as far as is desired. To show clearly the workings of the system, the divisions of Class 6 (useful arts) and the sections of Division 2 of this class (engineering) are given below:

600 Useful arts.	620 Engineering.
610 Medicine.	621 Mechanical.
620 Engineering.	622 Mining.
630 Agriculture.	623 Military.
640 Domestic science.	624 Bridge and roof.
650 Communication and commerce.	625 Road and railway.
660 Chemical technology.	626 Canal.
670 Manufactures	627 River and harbor.
680 Mechanic trades.	628 Sanitary.
690 Building.	629 Other branches.

It will be seen that the first digit gives the class; the second, the division; and the third, the section. Thus, 625 indicates Section 5 (road and railway engineering) of Division 2 (engineering) of Class 6 (useful arts). Further subdivision is indicated by the digits following the decimal point, which is placed as a matter of convenience after the section digit. For instance, 625.7 indicates highway engineering; 625.75, highway construction equipment; 625.753, highway consolidating machinery; 625,753.2, road rollers; 625.753.23, steam road rollers, and finally, 625.753.231, steam road rollers for macadam.

Following the classification list herein is the relative index, in which the terms of the classification are arranged alphabetically, each with its proper number. This index is manifestly incomplete, as it is impossible to include in it every subject that might come up in engineering practice. The skeleton is there, however, and the user may extend it further if he finds it advisable.

There are certain modifications in the use of the Dewey system. To avoid the writing of long numbers, a single letter may be used for the first three or four digits. Thus "H" might be used by a highway engineer in place of 625, "W" by a waterworks man in place of 628.1, and so forth.

Another modification consists in the use of an alphabetical arrangement for certain subsections where it is convenient, while retaining the decimal arrangement for the main divisions. For instance, under 625.821 (stone for macadam highways) the various varieties might be arranged alphabetically if desired. This is most useful where there are a large number of such minute divisions.

The use of "form divisions" is another useful modification. There are certain set forms, given on page 631, which are used throughout the range of the Dewey system. They may be still further extended thus:

064 Exhibits (under societies)
072 Laboratories (under universities)

They are usually enclosed in parentheses and annexed to the usual class number. Thus 62(07) indicates engineering education and 628.184(008) refers to patents regarding water sterilization and disinfection. If an engineer were particularly interested in patents, for example, he could reverse the usual manner of writing the class number and write it thus, (008)628.184, so that all the cards referring to patents would come together in his index.

Fig. 1 shows a set of cards for indexing a book or pamphlet and comprises both author and subject cards. These would be arranged alphabetically in the card drawers. To distinguish two cards having the same number, it is customary to write under the class number the initial or first two or three letters of the author's or publisher's name, though there are elaborate numerical lists published for this purpose.

625.892.212*

Gutter Construction for Streets and Road. T. Hugh Boorman. (Granite curbing and vitrified brick gutter)

Canadian Engineer. Sept. 14, 1914. XXVII. 473.

625.892.22*

Gutter Construction for Streets and Roads. T. Hugh Boorman. (Standard type of combined concrete curb and gutter.)

Canadian Engineer. Sept. 14, 1914. XXVII. 473.

625.95*

Gutter Construction for Streets and Roads. T. Hugh Boorman. (Preparation of curb and gutter construction materials: concrete, asphalt, brick, wood or stone.)

Canadian Engineer. Sept. 14, 1914. XXVII. 473.

Fig. 2.

For references to articles in the engineering press, the writer uses the form shown in Fig. 2. These cards are arranged numerically in the drawers, and it is necessary to find the class number of subject under investigation before referring to them. This class number may be found in the relative index. The asterisk after the class number indicates that the article in question is in the writer's clipping file.

Three years' experience with the system outlined has convinced the writer that it is as near perfection as it is possible to get. It requires some intelligent attention to keep it in shape, but that is true of any system. It is hoped that the lists herein will be of value to city engineers, superintendents of waterworks, streets and sewers and others in municipal engineering work.

Extension of the Dewey Decimal System of Classification to Cover Municipal Engineering.

FORM DIVISIONS.

01 Philosophy; theory.
02 Compends; text books; hand books; manuals.
03 Encyclopedias; dictionaries.
04 Essays; addresses.
05 Periodicals.
06 Societies.
07 Education; teaching; schools; colleges; universities.
08 Tables; diagrams, computations; tests; miscellanies.
09 History; progress; development.

001 Statistics; quantities.
002 Construction methods; costs.
003 Contracts; specifications.
004 Designs; drawings.
005 Executive; accounts; financial.
006 Working; maintenance.
007 Laws; rules; regulations; court decisions.
008 Patents.
009 Reports.

CLASS NUMBERS.

625.7 HIGHWAYS, ROADS AND STREETS.

.71 **Varieties.**

.711 Country roads.
.711.1 For heavy traffic; trunk highways.
.711.2 For medium traffic; inter-village roads.
.711.3 For light traffic.

.712 City streets.
.712.1 Thoroughfares.
.712.2 Minor streets.
.712.3 Streets for special purposes; motor roads; speedways.
.712.4 Alleys; lanes.
.712.5 Squares; public gardens.

.72 **Traffic.**

.721 Weight.
.722 Distribution.
.723 Effects.
.724 Censuses; counts.

.73 **Surveys and Designs.**

.731 Preliminary surveys; reconnaisances.
.732 Location surveys; staking out.
.733 Profiles.
.734 Curvature.
.734.1 Widening.
.734.2 Superelevation.

.74 **Features.**

.741 Alignment.
.742 Cross section.
.743 Crown.
.744 Slopes.
.745 Drainage.
.746 Accessories.
.746.1 Gutters; catch basins; gullies; inlets.
.746.2 Retaining walls; guard rails; parapets.
.746.3 Bridges; culverts.
.746.4 Milestones; signs; mirrors.
.746.5 Lighting; lamp posts.
.746.6 Other features.

.75 **Construction Equipment.**

.751 Excavating and grading machinery.
.751.1 Hand tools.
.751.2 Scrapers.
.751.3 Drags.
.751.4 Plows; scarifiers.
.751.5 Elevating graders.
.751.6 Trenching machinery.
.751.7 Power shovels.
.751.8 Other appliances.

.752 Hauling machinery.
.752.1 Wheelbarrows.
.752.2 Wagons; carts.
.752.3 Auto trucks.
.752.31 Steam.
.752.32 Gasoline.
.752.33 Electric.
.752.4 Cars.
.752.41 Dumping.
.752.42 Non-dumping.
.752.5 Locomotives.
.752.51 Steam.
.752.52 Gasoline; oil.
.752.53 Electric.
.752.54 Compressed air.
.752.6 Tractors.
.752.61 Steam.
.752.62 Gasoline or oil.
.752.7 Tractor wagons.
.752.8 Other machinery.

.753 Consolidating machinery.
.753.1 Tampers.
.753.11 Hand.
.753.12 Power.
.753.2 Rollers.
.753.21 Hand.
.753.22 Horse.
.753.23 Steam.
.753.231 Macadam.
.753.232 Asphalt.
.753.24 Gasoline or oil.
.753.241 Macadam.
.753.242 Asphalt.

.754 Quarrying and stone working machinery.
.754.1 Hand tools.
.754.2 Drills.
.754.3 Derricks.
.754.4 Cableways.
.754.5 Hoists.
.754.51 Hand.
.754.52 Horse.
.754.53 Steam.
.754.54 Gasoline or oil.
.754.55 Electric.
.754.56 Compressed air.
.754.6 Block splitters.
.754.7 Other appliances.

.755 Crushed stone, gravel and sand machinery.
.755.1 Hand tools.
.755.2 Crushers.
.755.21 Gyratory.
.755.22 Jaw.
.755.23 Rotary.
.755.24 Hammer or impact.
.755.3 Screens.
.755.31 Rotary.
.755.32 Shaking.
.755.33 Stationary.
.755.4 Washers.
.755.5 Heaters.
.755.6 Bins.
.755.7 Other appliances.

.756 Brick machinery.
.756.1 Clay mills.
.756.2 Brick machines.
.756.3 Dryers.
.756.4 Kilns.
.756.5 Other machinery.

.757 Concrete machinery.
.757.1 Mixers.
.757.11 Continuous.
.757.12 Batch.
.757.13 Gravity.
.757.2 Conveyers.
.757.21 Buggies; wheelbarrows.
.757.22 Buckets.
.757.23 Continuous; belts; pneumatic.
.757.3 Other appliances.

.758 Asphalt machinery.
.758.1 Hand tools.
.758.2 Mining appliances.
.758.3 Refinery appliances; stills; tanks.
.758.4 Hot mixers.
.758.5 Kettles; heaters.
.758.6 Other machinery.

.759 Wood block machinery.
.759.1 Hand tools.
.759.2 Special saws, etc.
.759.3 Dry kilns.
.759.4 Tanks.
.759.5 Treating cylinders.
.759.6 Pumps.
.759.7 Conveyers; transporters.
.759.8 Other appliances.

.76 **Maintenance.**

.761 Dragging; scraping.
.762 Rolling.
.763 Sprinkling.
.763.1 With water.
.763.2 With chemical solutions.
.764 Oiling; tarring.
.765 Treating with other materials.
.766 Sweeping.
.766.1 Patrol system.
.766.2 Horse or auto brooms.
.767 Vacuum cleaning.
.768 Flushing.
.768.1 With hose by hand.
.768.2 With horse or auto flushers.
.769 Miscellaneous methods of maintenance.
(For repairs, see under paving material in question).

.77 **Cultivation.**

.771 Tree planting
.771.1 Species.
.771.2 Arrangement.
.771.3 Care; maintenance.

.772 Boulevard space; parking.
.772.1 Lawns.
.772.2 Flower beds.

.773 Flower boxes.
.773.1 On electric light or trolley poles.

.78 **Sanitation.**

.79 **Other General Matter.**

625.8 PAVING MATERIALS.

.81 **Earth.**

.811 Sand-clay; top-soil.
.812 Gravel.
.813 Burnt-clay; ballast.
.814 Other earthy materials.

.82 **Macadam and Telford.**

.821 Stone.
.821.1 Trap.
.821.2 Limestone.
.821.3 Granite.
.821.4 Basalt.
.821.5 Porphyry.
.821.6 Other stones.

.83 **Stone Blocks.**

.831 Stone.
.831.1 Granite.
.831.2 Sandstone.
.831.3 Limestone.
.831.4 Basalt.
.831.5 Lava.
.831.6 Porphyry.
.831.7 Other stones.

.832 Joint fillers.
.832.1 Sand.
.832.2 Pitch; coal tar products.
.832.3 Asphalt.
.832.4 Cement grout.
.832.5 Wood.
.832.6 Other materials.

.84 **Brick.**

.841 Ordinary brick.
.842 Vitrified brick.
.843 Vitrified block.
.844 Scoria block.
.845 Other similar materials.
(For jointing materials see under 625.832 above).

.85 **Wood Block.**

.851 Wood.
.851.1 Yellow pine.
.851.2 British Columbia or Oregon fir.
.851.3 Norway deal.
.851.4 Jarrah.
.851.5 Karri.
.851.6 Other woods.

.852 Preservation.
.852.1 Creosoting.
.852.2 Kyanizing.
(For jointing materials see under 625.832 above).

.86 **Concrete.**

.861 Cement.
.862 Sand.
.863 Gravel.
.864 Crushed stone.
.865 Water.
.866 Joints.
.866.1 Protection devices.

.867 Surfacing materials.
.867.1 Asphalt.
.867.2 Coal tar products.
.867.3 Mortar; granolithic.
.867.4 Other materials.

.868 Reinforcement.
.868.1 Bars.
.868.2 Fabric.

.87 **Asphalt and Bituminous Macadam**

.871 Asphalt.
.871.1 For sheet asphalt.
.871.2 For asphalt blocks.
.871.3 For mixing method.
.871.4 For penetration method.

.872 Coal tar products.
.872.1 For mixing method.
.872.2 For penetration method.
.873 Fluxes.
.874 Crushed stone.
.875 Gravel.
.876 Sand.

.88 **Other Paving Materials.**
.881 Shells.
.882 Slag.
.883 Cinders.
.884 Other materials.

.89 **Sidewalks and Curbing.**
.891 Sidewalks; crosswalks.
.891.1 Arrangement.
.891.11 Slope.
.891.12 Grade.
.891.13 Width.
.891.14 Position.
.891.2 Materials.
.891.21 Earth; gravel; cinders.
.891.22 Wood.
.891.23 Brick; tile.
.891.24 Stone; flagging.
.891.25 Concrete; artificial stone flags.
.891.26 Asphalt; coal tar products.
.891.27 Other materials.

.892 Curbing.
.892.1 Arrangement.
.892.11 Size.
.892.12 Shape.
.892.2 Materials.
.892.21 Stone.
.892.211 Limestone.
.892.212 Granite.
.892.213 Sandstone.
.892.214 Other stones.
.892.22 Concrete.
.892.221 Corner protection.
.892.222 Reinforcement.
.892.23 Wood.
.892.24 Vitrified clay.
.892.25 Other materials.

625.9 CONSTRUCTION.

.91 **Subgrade.**
.911 Excavation.
.912 Consolidation.
.913 Ditching and drainage.

.92 **Foundation.**
.921 Preparing material.
.921.1 Telford.
.921.2 Macadam.
.921.3 Concrete.
.921.4 Other materials.
(For methods of mixing, placing, spreading, consolidating, etc., see under 625.942 and 625.945, and so forth).

.93 **Cushion.**
.931 Sand.
.932 Mortar.
.933 Other materials.

.94 **Wearing Surface.**
.941 Earth.
.941.1 Gravel.
.941.2 Sand-clay; top-soil.
.941.3 Burnt-clay; ballast.
.941.4 Other earthy materials.
1 Spreading; 2 Shaping; 3 Rolling; tamping; 4 Finishing.

.942 Macadam; telford.
.942.1 Spreading stone.
.942.2 Consolidating.
.942.3 Sprinkling.
.942.4 Accessory construction.

.943 Block paving; stone; brick; wood block; asphalt block.
.943.1 Distributing blocks.
.943.2 Placing blocks.
.943.3 Consolidating blocks.
.943.4 Jointing blocks.

.944 Asphalt; bituminous macadam.
.944.1 Mixing material.
.944.2 Distributing material.
.944.3 Consolidating material.
.944.4 Sprinkling with oil, tar or asphalt.

.945 Concrete.
.945.1 Mixing materials.
.945.2 Distributing materials.
.945.3 Consolidating materials.

.946 Other kinds of paving.

.95 **Sidewalks and Curbing.**
.951 Preparing materials.
.952 Placing.
.953 Jointing.
.954 Other operations.

.06 **Street Railways.**
.961 Preparing the foundation.
.962 Laying the track.
.963 Paving between and adjacent to rails.

628. **SANITARY ENGINEERING.**

628.1 WATER SUPPLY.

.11 **Sources of Supply.**
.111 Lakes and ponds.
.111.1 Quality.
.111.11 Physical.
.111.12 Chemical.
.111.13 Bacteriological.
.111.14 Protection of quality; prevention of pollution.
.111.15 Other data.

.112 Flowing streams; rivers; brooks; creeks; impounding reservoirs.
.112.1 Quality.
.112.11 Physical.
.112.12 Chemical.
.112.13 Bacteriological.
.112.14 Protection of quality; prevention of pollution.
.112.15 Other data.

.113 Underground waters; springs; wells; galleries.
.113.1 Quality.
.113.11 Physical.
.113.12 Chemical.
.113.13 Bacteriological.
.113.14 Protection of quality; prevention of pollution.
.113.15 Other data.

.114 Yield.
.114.1 Rainfall.
.114.11 Amount.
.114.12 Rate.
.114.13 Distribution.
.114.14 Other data.
.114.2 Evaporation.
.114.21 From land area.
.114.22 From water surface.
.114.23 Other data.
.114.3 Percolation.
.114.4 Runoff.
.114.5 Underground waters.
.114.51 Pumping tests.
.114.6 Other data on yield.

.115 Consumption.
.115.1 Domestic.
.115.11 Amount.
.115.12 Variation.
.115.13 Other data.
.115.2 Industrial.
.115.21 Amount.
.115.22 Variation.
.115.23 Other data.
.115.3 Public (except fire).
.115.31 Amount.
.115.32 Variation.
.115.33 Other data.
.115.4 Fire protection.
.115.41 Amount.
.115.42 Other data.
.115.5 Waste.
.115.51 Amount.
.115.52 Detection.
.115.521 By inspection.
.115.522 By metering.
.115.523 By Deacon meter.
.115.524 By pitometer.
.115.525 By pulsograph.
.115.526 By other methods.
.115.53 Prevention.
.115.531 By inspection.
.115.532 By metering.
.115.533 By other methods.
.115.6 Total consumption.
.115.61 Quantity.
.115.62 Variation.
.115.621 Hourly.
.115.622 Daily.
.115.623 Weekly.
.115.624 Monthly; seasonal.
.115.625 Annual.
.115.63 Other data.

.116 Pressure.
.116.1 For domestic use.
.116.2 For industrial use.
.116.3 For public use.
.116.4 For fire protection.
.116.5 For other purposes.
.116.6 Gauges.
.116.61 Indicating.
.116.62 Recording.
.116.7 Other data.

.12 **Hydraulics.**
.121 Of canals; conduits; pipe lines.
.122 Of fire streams; hose; nozzles.
.123 Of distribution system.
.124 Of pumping machinery.

.125 Measuring devices.
.125.1 Weirs.
.125.2 Orifices.
.125.3 Meters.
.125.4 Pitometers; pitot tubes.
.125.5 Other devices.

.126 Other hydraulic questions.

.13 **Collection of Water.**
.131 Impounding reservoirs.
.131.1 Dams.
.131.11 Earth.
.131.12 Rock fill.
.131.13 Masonry; concrete.
.131.14 Wood.
.131.15 Steel.
.131.16 Other materials.
.131.2 Outlets.
.131.21 Tunnels.
.131.22 Towers.
.131.23 Other devices.

.132 Diversion.
.132.1 Dams.
.132.11 Earth.
.132.12 Rock fill.
.132.13 Masonry; concrete.
.132.14 Wood.
.132.15 Steel.
.132.16 Other materials.

.133 Underground water collection.
.133.1 Wells.
.133.11 Shallow.
.133.111 Large open.
.133.112 Driven.
.133.12 Deep.
.133.2 Springs.
.133.21 Spring basins.
.133.3 Galleries.
.133.4 Other devices.
.134 Other adjuncts.

.14 **Pumping.**
.141 Intakes.
.141.1 Cribs.
.141.2 Towers.
.141.3 Screens.
.141.4 Other devices.

.142 Suction wells.

.143 Steam plant.
.143.1 Boilers.
.143.11 Fire tube.
.143.12 Water tube.
.143.13 Other types.
.143.2 Fuel handling machinery.
.143.21 Cars.
.143.22 Trolleys.
.143.23 Conveyers.
.143.3 Chimneys.
.143.4 Forced and induced draft apparatus.
.143.5 Feed pumps.
.143.6 Condensers.
.143.61 Surface.
.143.62 Jet.
.143.63 Barometric.
.143.64 Air pumps and auxiliaries.
.143.7 Engines.
.143.71 Reciprocating.
.143.711 Low speed.
.143.712 High speed.
.143.713 Turbines.
.143.713.1 Impulse.
.143.713.2 Reaction.
.143.8 Piping.
.143.9 Miscellaneous appliances.

.144 Water power plant.
.144.1 Turbines.
.144.2 Pelton wheels.
.144.3 Overshot wheels.
.144.4 Governors.
.144.5 Other devices.

.145 Gas plant.
.145.1 Producers.
.145.2 Purifiers.
.145.3 Gasometers.
.145.4 Engines.
.145.5 Other appliances.

.146 Electric plant.
.146.1 Generators.
.146.11 Direct current.
.146.12 Alternating current.
.146.2 Switch gear.
.146.3 Transformers.
.146.4 Transmission line.
.146.5 Motors.
.146.51 Direct current.
.146.52 Alternating current.
.146.6 Other appliances.

.147 Compressed air plant.
.147.1 Compressors.
.147.2 Storage tanks.
.147.3 Pipe lines.
.147.4 Other appliances.

.148 Pumps.
.148.1 Reciprocating.
.148.11 Steam.
.148.12 Hydraulic.
.148.13 Power.
.148.2 Rotary.
.148.3 Centrifugal.
.148.4 Pneumatic.
.148.41 Displacement.
.148.42 Air lift.
.148.5 Gas.
.148.51 Humphrey.
.148.6 Other varieties.

.15 **Storage and Service Reservoirs.**
.151 Surveys; design.
.152 Surface.
.152.1 Earth.
.152.11 Open.
.152.12 Covered.
.152.2 Masonry; concrete.
.152.21 Open.
.152.22 Covered.

.153 Elevated.
.153.1 Tanks.
.153.11 Wood.
.153.12 Iron; steel.
.153.13 Masonry; concrete.
.153.14 Other materials.
.153.2 Standpipes.
.153.21 Wood.
.153.22 Iron; steel.
.153.23 Masonry; concrete.
.153.24 Other materials.

.154 Adjuncts.
.154.1 Inlets.
.154.2 Outlets.
.154.3 Overflows.
.154.4 Drains.
.154.5 Regulators; automatic valves.
.154.6 Other devices.

.16 **Canals, Conduits and Aqueducts.**
.161 Surveys; designs.
.162 Open canals.
.162.1 Unlined.
.162.2 Lined.
.162.3 Flumes.
.162.31 Wood.
.162.32 Metal.
.162.33 Other materials.

.163 Closed conduits.
.163.1 Tunnels.
.163.11 Unlined.
.163.12 Lined.
.163.2 Aqueducts.
.163.21 Stone; brick.
.163.22 Concrete.
.163.3 Pipe lines.
.163.31 Wood.
.163.32 Iron; steel.
.163.33 Other materials.
(For mains and services, see 628.17 below).

.164 Adjuncts.
.164.1 Gates; valves.
.164.2 Relief valves.
.164.3 Air valves.
.164.31 Inlet.
.164.32 Outlet.
.164.4 Blowoffs; drains.
.164.5 Other adjuncts.

.17 **Mains and Services.**
.171 Surveys; designs.
.172 Mains.
.172.1 Cast iron.
.172.2 Wrought iron; steel.
.172.21 Seamless.
.172.22 Welded.
.172.23 Rivetted.
.172.24 Lock bar.
.172.25 Other types.
.172.3 Wood.
.172.31 Bored.
.172.32 Stave.
.172.4 Other forms of mains

.173 Joints.
.173.1 Turned and bored.
.173.2 Flanged and bolted.
.173.3 Leaded.
.173.31 Poured.
.173.32 Lead wool.
.173.4 Wood wedges.
.173.5 Leadite.
.173.6 Other materials.

.174 Coatings.
.174.1 Angus Smith solution.
.174.2 Asphaltic preparations.
.174.3 Jute wrapping.
.174.4 Other methods.
.174.5 Electrolysis.
.174.51 Causes.
.174.52 Prevention.

.175 Accessories.
.175.1 Gates; valves.
.175.2 Hydrants.
.175.3 Hatch boxes for cleaning.
.175.4 Other details.

.176 Services.
.176.1 Lead; tin-lined lead.
.176.2 Tin.
.176.3 Wrought iron; steel.
.176.31 Black.
.176.32 Galvanized.
.176.33 Cement lined.
.176.4 Other materials.

.177 Appurtenances.
.177.1 Shut-off cocks.
.177.2 Other appliances.

.18 **Removal of Impurities.**
.181 Sedimentation.
.181.1 Plain.
.181.2 With coagulant.

.182 Storage, effect on quality.

.183 Filtration.
.183.1 Slow sand filtration.
.183.11 Sedimentation basins.
.183.12 Filter beds.
.183.121 Drainage systems.
.183.13 Operating devices.
.183.131 Cleaning devices.
.183.131.1 Scrapers.
.183.131.2 Sand washers.
.183.131.3 Blaisdell machine.
.183.131.4 Other devices.
.183.14 Clear water basins.
.183.2 Rapid filtration.
.183.21 Coagulation basins.
.183.211 Chemical mixing devices.
.183.212 Chemical feeding machinery.
.183.22 Filter beds.
.183.221 Drainage systems.
.183.222 Washing systems.
.183.222.1 Blowers.
.183.222.2 Air storage tanks.
.183.222.3 Air piping.
.183.222.4 Mechanical agitators.
.183.23 Operating devices.
.183.24 Clear water basins.

.184 Disinfection; sterilization.
.184.1 By copper sulphate.
.184.2 By hypochlorite of lime.
.184.3 By hypochlorite of soda.
.184.4 By liquid chlorine.
.184.5 By ozone.
.184.6 By ultra-violet rays.
.184.7 By other methods.

.19 **Special Water Works Appliances.**
.191 Trenching machinery.
.192 Cleaning apparatus for mains.
.193 Jointing machines.
.194 Tapping machines.
.195 Other devices.

628.2 SEWERAGE.

.21 **Preliminary Investigations.**
.211 Surveys; maps; plans; profiles.
.212 Borings; test pits.
.213 Population.
.214 Measurements; gaugings.
.215 Other data.

.22 **Sewerage Systems.**
.221 Isolated.
.221.1 Privies; latrines.
.221.2 Earth closets.
.221.3 Cesspools.
.221.4 Incinerators.
.221.5 Other devices.

.222 Collective.
.222.1 Pneumatic.
.222.11 Berlier.
.222.12 Liernur.
.222.13 Other systems.
.222.2 Water carriage.
.222.21 Separate.
.222.22 Combined.

.23 **Design.**
.231 Size.
.231.1 Sanitary sewers.
.231.2 Storm water drains.
.231.21 Formulas.
.231.22 Rational methods. (For rainfall data see 628.114).
.231.3 Infiltration; leakage.
.231.4 Other data.

.232 Shape.
.232.1 Circular.
.232.2 Egg-shaped.
.232.3 Horseshoe.
.232.4 Parabolic; semi-elliptical; catenary; basket handle.
.232.5 Rectangular.
.232.6 Other shapes.

.233 Velocity.
.233.1 In sanitary sewers.
.233.2 In storm water drains.
.233.3 Erosion.
.233.4 Grades.
.233.5 Other data.

.234 Ventilation.
.234.1 Sewer air; "sewer gas"; explosions.
.234.2 By omitting house traps.
.234.3 By use of perforated manhole covers, etc.
.234.4 By special shafts, etc.
.234.5 By connection to chimneys.
.234.6 By mechanical methods; fans.
.234.7 By other means.

.24 **Sewer Sections.**
.241 Pipe.
.241.1 Clay.
.241.2 Concrete.
.241.3 Jointing materials.
.241.31 Cement.
.241.32 Asphalt.
.241.33 Sulphur and sand.
.241.34 Cement and tar.
.241.35 Other materials.
.242 Brick; stone.
.243 Concrete.
.244 Wood.
.245 Other materials.
.246 In combination with other structures.

.25 **Appurtenances.**
.251 Manholes; lampholes; ventilating shafts.
.251.1 Regular.
.251.2 Drop.
.251.3 Special.
.252 Catch basins; gullies; inlets.
.253 Flush tanks.
.254 House connections.
.255 Outlets.
.256 Other appurtenances.

.26 **Special Structures.**
.261 Stream crossings.
.261.1 Bridges.
.261.2 Inverted siphons.
.262 Overflows.
.262.1 Weirs.
.262.2 Regulators.
.262.3 Other types.
.263 Flood and tide gates.
.264 Reservoirs; tank sewers.
.265 Pumping stations.
.265.1 Automatic.
.265.11 Compressed air.
.265.12 Electric.
.265.13 Other types.
.265.2 Non-automatic.
.265.21 Steam.
.265.22 Electric.
.265.23 Gas, gasoline or oil.
.265.24 Other types.
.266 Other special structures.

.27 **Special Construction Appliances.**
.271 Excavators.
.272 Material handling devices.
.273 Forms; centres.
.274 Jointing appliances.
.275 Unwatering devices.
.276 Other appliances.

.28 **Operation and Maintenance.**
.281 Cleaning.
.281.1 Scraping.
.281.11 Hand.
.281.12 Power.
.282 Flushing.
.282.1 Tank carts.
.282.2 By hand with hose.
.282.3 By damming sewage.

.29 **Other Material Regarding Sewerage**

628.3 SEWAGE DISPOSAL.

.31 **Composition of Sewage.**
.311 Physical.
.312 Chemical.
.313 Bacteriological.
.314 Other data.

.32 **Disposal by Dilution.**
.321 Surveys; designs.
.321.1 Soundings.
.321.2 Current and tide observations.
.321.3 Stream flow.
.321.4 Other data.
.322 Outlets.
.322.1 Single.
.322.11 Non-submerged.
.322.12 Submerged.
.322.2 Multiple.
.322.21 Non-submerged.
.322.22 Submerged.
.323 Other data regarding disposal by dilution

.33 **Screening.**
.331 Coarse screens.
.331.1 Bar screens.
.331.2 Fabric screens.
.331.3 Horizontal.
.331.4 Inclined.
.331.5 Other types.
.332 Fine screens.
.332.1 Stationary.
.332.2 Moving.
.332.21 Cylindrical.
.332.22 Band.
.332.23 Other varieties.
.333 Other types of screens.

.334 Screen cleaning apparatus.
.334.1 Jets.
.334.2 Brushes.
.334.3 Scrapers.
.334.4 Other devices.

.34 **Plain Sedimentation.**

.341 Grit chambers.
.342 Tanks.
.342.1 Shallow.
.342.2 Dortmund.
.342.3 Two story.
.342.31 Travis-Hampton.
.342.32 Imhoff or Emscher.
.342.321 Horizontal flow.
.342.322 Radial flow.
.342.4 Septic.
.342.5 Secondary, for treating filter effluent.
.342.6 Other types.

.343 Appurtenances.
.343.1 Movable weirs.
.343.2 Scum boards.
.343.3 Baffles.
.343.4 Inlets.
.343.5 Outlets.
.343.6 Ventilating devices.
.343.7 Other appliances.
.344 Other data on plain sedimentation.

.35 **Chemical Precipitation.**

.351 By lime.
.352 By salts of iron.
.353 By salts of aluminum.
.354 By other chemicals.
(For data on tanks see 628.34 above).

.36 **Sludge Disposal.**

.361 Dumping at sea; flushing into rivers.
.362 Pressing.
.363 Burial.
.364 Sludge beds.
.365 Lagooning.
.366 Centrifugal drying.
.367 Other methods.

.37 **Filtration.**

.371 Sewage farming; broad irrigation.
.371.1 Arrangement.
.371.2 Application of sewage.
.371.3 Drainage.
.371.4 Other details.

.372 Intermittent sand filtration.
.372.1 Beds.
.372.11 Filtering material.
.372.12 Application of sewage.
.372.13 Drainage.
.372.14 Other details.
.372.2 Dosing apparatus.
.372.3 Other details.

.373 Contact beds.
.373.1 Beds.
.373.11 Dibdin beds.
.373.2 Dosing apparatus.
.373.3 Filtering material.
.373.4 Drainage.
.373.5 Other details.

.374 Sprinkling filters.
.374.1 Beds.
.374.11 Filtering material.
.374.12 Application of sewage.
.374.121 Splash plates.
.374.122 Nozzles.
.374.123 Distributers.
.374.2 Dosing apparatus.
.374.3 Drainage.
.374.4 Other details.
.375 Other types of filters.

.38 **Sterilization and Disinfection.**

.381 By hypochlorite of lime.
.382 By hypochlorite of soda.
.383 By liquid chlorine.
.384 By electrolytic processes.
.385 By lime.
.386 By other methods.

.39 **Operation and Maintenance.**

.391 Methods of control; analyses.
.392 Operating methods.
.393 Maintenance methods.
.393.1 For disposal by dilution.
.393.2 For screening.
.393.3 For filtration.
.393.31 Sewage farms.
.393.32 Intermittent sand filters.
.393.33 Contact beds.
.393.34 Sprinkling filters.
.393.35 Other forms of filters.
.393.4 For sterilization and disinfection.
.393.5 For other methods of disposal.
.394 Operating results.
.395 Other data.

628.4 TOWN AND CITY SANITATION.

.41 **Refuse Disposal.**

.411 Garbage.
.411.1 Composition.
.411.2 Amount.
.411.3 Variation.
.411.4 Other data.

.412 Rubbish.
.412.1 Composition.
.412.2 Amount.
.412.3 Variation.
.412.4 Other data.

.413 Ashes.
.413.1 Composition.
.413.2 Amount.
.413.3 Variation.
.413.4 Other data.

.414 Collection.
.414.1 Separately.
.414.2 Combined.
.414.3 Other data.

.415 Disposal.
.415.1 By dumping.
.415.2 By burial.
.415.3 By feeding to hogs, (garbage only).
.415.4 By incineration.
.415.5 By reduction, (garbage only).
.415.6 By utilization; picking; sorting, (rubbish only).
.415.7 By other methods.

.42 **Convenience Stations.**

.43 **Public Baths and Laundries.**

.44 **Slaughter House and Abattoirs.**

.45 **Morgues, Cemeteries and Crematories.**

.46 **Smoke Prevention.**

.47 **Other Questions of Municipal Sanitation.**

Relative Index for the Dewey Decimal System of Classification to Cover Municipal Engineering.

A.

Abattoirs	628.44
Accessory features of roads	625.746
Adzes	625.759.1
Agitators, mechanical	628.183.222.4
Air of sewers	628.234.1
Air, compressed, plant	628.147
" compressors	628.147.1
" lift	628.148.42
" piping	628.183.222.3
" pumps	628.143.64
" storage tanks	628.183.222.2
" valves	628.164.3
Alignment of roads	625.741
Alleys	625.712.4
Alternating current generators	628.146.12
" " motors	628.146.52
Aluminum, salts of, in chemical precipitation	628.353
Amount of ashes	628.413.2
" " domestic water consumption	628.115.11
" " garbage	628.411.2
" " industrial water consumption	628.115.21
" " public water consumption, (except fire)	628.115.31
" " rainfall	628.114.11
" " rubbish	628.412.2
" " water waste	628.115.51
Analyses, sewage	628.391
Annual variation of total water consumption	628.115.625
Appliances for cleaning water mains	628.192
" " " sewers	628.334
" " jointing sewers	628.274
Application of sewage to intermittent sand filters	628.372.12
" " " " farms	628.371.2
" " " " sprinkling filters, (see "splash plates, nozzles, distributers")	628.374.12
Aqueducts, (see "stone, brick, concrete")	628.163.2
Arrangement of curbing	625.892.1
" " sewage farms	628.371.1
" " sidewalks	625.891.1
" " trees	625.771.2
Ash handling machinery	628.143.2
Ashes, (see "composition, amount, variation")	628.413
Asphalt for blocks	625.871.2
" " joint filler	625.832.3
" " mixing method	625.871.3
" " paving	625.871
Asphalt for penetration method	625.871.4
" " sheet asphalt	625.871.1
" " sidewalks	625.891.26
" " surfacing concrete roads.	625.867.1
" distributing	625.944.2
" heaters	625.758.5
" joints for sewer pipe	628.241.32
" kettles	625.758.5
" machinery	625.758
" mining apparatus	625.758.2
" mixing	625.944.1
" refining apparatus	625.758.3
" rolling	625.944.3
" rollers, gasoline or oil	625.753.242
" " steam	625.753.232
" stills	625.758.3
" tanks	625.758.3
Asphaltic preparations for coating mains	628.174.2
Auto trucks, (see "steam, gasoline, electric")	625.752.3
Automatic sewage pumping stations, (see "compressed air, electric")	628.265.1
Automatic valves for reservoirs, etc.	628.154.5

B.

Bacteriological composition of sewage	628.313
" quality of underground water	628.113.13
" " " lake and pond water	628.111.13
" " " stream and impounding reservoir water	628.112.13
Baffles for sewage tanks, etc.	628.343.3
Ballast, (paving material)	625.813
Ballast wearing surface	625.941.3
Band fine screens	628.332.22
Bar coarse screens	628.331.1
Barometric condensers	628.143.63
Bars, reinforcing	625.868.1
Basalt for macadam	625.821.4
" " stone blocks	625.831.4
Basins for springs	628.133.21
" clear water, (slow sand)	628.183.14
" " " (rapid)	628.183.24
" coagulation	628.183.21
" sedimentation, for water	628.183.11
Basket-handle sewers	628.232.4
Batch concrete mixers	625.757.12
Baths, public	628.43

D.

E.

F.

G.

T.

U.

V.

W.

Y.

MAIN PEDESTALS, QUEBEC BRIDGE

NOTES ON THE DESIGN OF THE FOUR 400-TON SHOES TO TRANSFER THE LOAD FROM THE CANTILEVER AND ANCHOR ARMS TO THE MAIN PIERS—METHOD OF FABRICATION AND ASSEMBLAGE.

By H. P. BORDEN,
Assistant to Chief Engineer, Quebec Bridge.

Each of the four main shoes of the new Quebec Bridge are designed to transfer the following loads:

Main vertical post	26,600,000 lbs.
Cantilever arm chord	29,600,000 lbs.
Anchor arm chord	24,100,000 lbs.
Cantilever arm Compression diagonal	7,820,000 lbs.
Anchor arm compression diagonal	7,810,000 lbs.

Resolving the above, this pedestal supports a maximum vertical and horizontal reaction of 55,000,000 and 32,000,000 lbs. respectively. Owing to the unprecedented size of the members required to transfer these loads to the shoe and the necessarily unusual proportions of the shoe itself which is required to distribute these loads to the masonry, the design of this member probably entailed more investigation and study than any other single detail in connection with the bridge.

The shoe is 26 ft. 4 in. x 20 ft. 10 in. at the base and 19 ft. high. To facilitate fabrication, shipping and erection, it is constructed in three stories. The lower story, or base, is 4 ft. high and is composed of 4 steel castings. These castings probably constitute a record for weight and size of steel castings in Canada, weighing over 40 tons each. These members have webs and flanges ranging from 2½ in. to 3 in. in thickness, the webs being supported by cross diaphragm walls of the same thickness, at frequent intervals. These castings are planed on a machine designed especially for this purpose, great care being taken to get a uniform depth for each of the 4 castings. When erected in place they are bolted together with 2½-in. bolts through exterior flanges, thus forming a base through which the vertical and horizontal reactions from the upper portions of the shore are transmitted to the masonry. The horizontal reactions at the

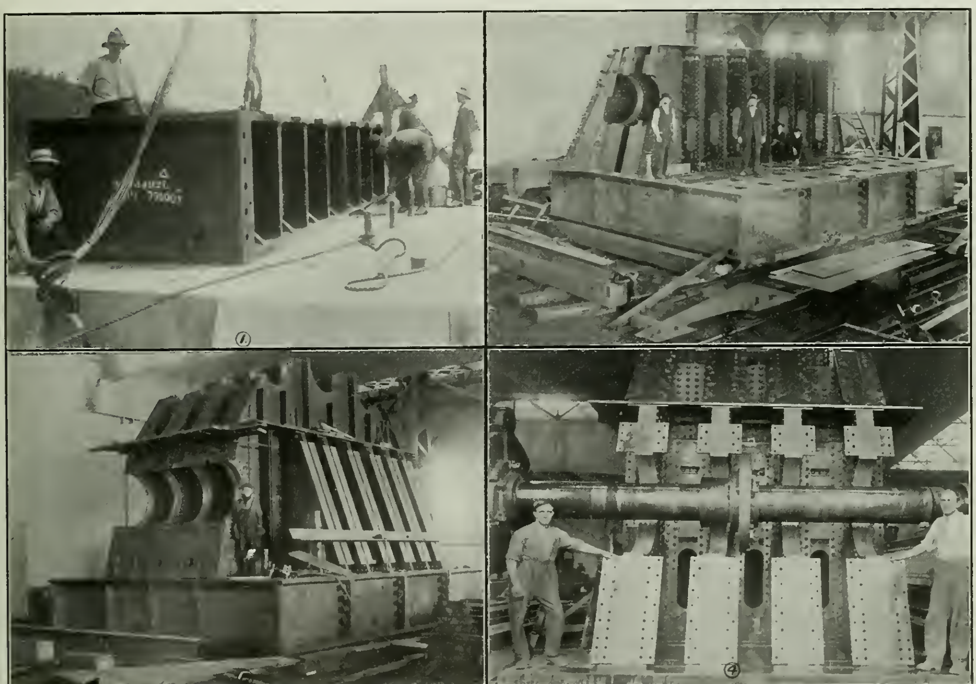


Fig. 1.—One of the 4 Castings Being Placed on the Pier. Fig. 2.—Casting Assembled (shop) and Second Story Under Construction. Fig. 3.—Second and Third Stories Nearing Completion. Fig. 4.—Method of Boring 45-inch Pin-hole.

pier can in every case be taken care of by the 30% coefficient of friction assumed between steel and masonry, but an additional factor of safety is provided by 44 3-in. anchor bolts and dowels. The dowels in the interior of the castings are grouted into the masonry and embedded in concrete with which the casting will be filled. The anchor bolts through the exterior lower flanges of the castings are grouted into the masonry with cement, that portion of bolt passing through the steel flange being grouted with molten zinc.

The middle section of the shoe is of built-up construction and is field-riveted to the lower section. This portion of the member is 10 ft. high and is composed mainly of 4 heavy webs which correspond to the webs of the bottom chords. The chord stresses are transmitted direct to this section of the shoe through 30-in. pins with 45-in. bushings. In addition to the chord stresses, this section of the shoe is required to transmit the stresses from the other web members which is transferred from the upper section and as a consequence the webs of the middle section become very heavy, the maximum thickness at the pin being 9¼ in., requiring a 1⅛-in. rivet 12 in. long. The loads distributed upon these webs are transferred uniformly to the base by means of 7 heavy brackets on each side, field riveted to both webs and castings. It was found when designing the connections between brackets and webs that the largest angles rolled would not provide sufficient rivet area to transmit the vertical shear. As a result, special connection-angles with 12-in. legs were manufactured from 1-in. plates. While it is expected that this design will undoubtedly to a large extent distribute the loads uniformly over the lower section, yet the contingencies of fabrication and erection are such that the actual results might not correspond to the theoretical expectations. To provide against the possibility of the load on the centre webs not distributing as expected, the steel castings on the base have been made sufficiently strong to distribute any such concentrated loading. The connection plates for the main bottom laterals are field riveted to the top and bottom of this section. When it is understood that these laterals have an inclination in both the vertical and horizontal plane and the face of the shoe to which they are connected is sloped at another angle in the vertical plane, it speaks well for the accuracy of the shop work that the connection holes in all these parts matched exactly when the shoe came to be assembled.

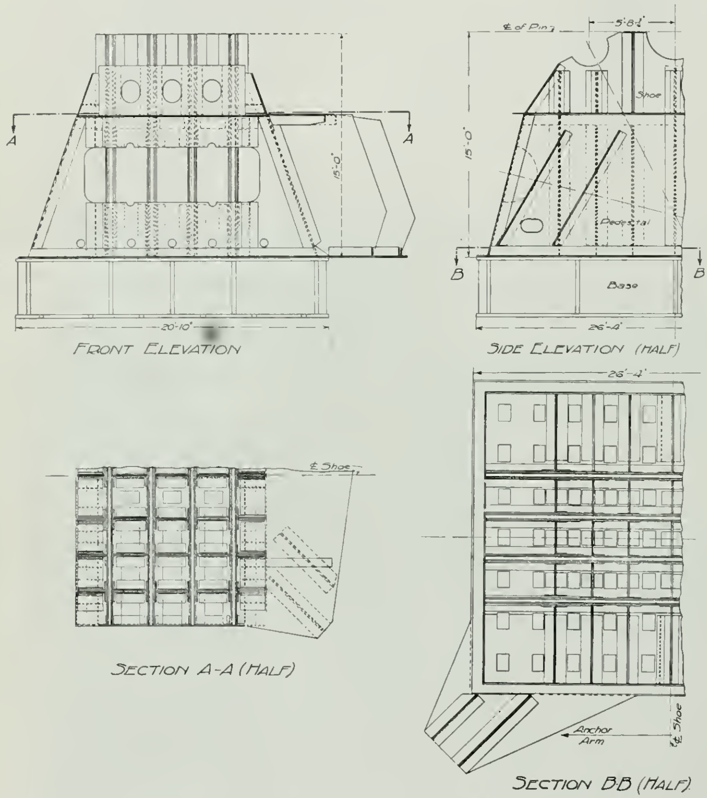


Fig. 5.—Elevations and Sections of Shoe for Main Pier Bearing.

The top or third section contains one 45-in. and two 30-in. half-pin holes which take the bushing for the 30- and 20-in. pins of the main post and diagonal compression members respectively. This section has 4 main webs which correspond to the 4 webs of the web members and post as well as the webs of the second section immediately below. In order to uniformly distribute the reaction, brackets are connected to the sides of the outer webs, spaced to correspond to the lower brackets. This top section is braced by very heavy brackets and diaphragms so that, assuming the whole shoe to act as a girder, transversely, the top and bottom stories will act as the flanges and the middle story as the web.

The maximum vertical loads on the shoe result in a uniform bearing of 660 lbs. per sq. in. on the granite masonry of the pier. This reaction comes from dead load, live load, impact, traction and vertical wind. In addition to the above there are transverse and longitudinal wind loads of 1,300,000 and 6,200,000 lbs. respectively. The transverse force is the horizontal component of the wind forces carried to the shoe by the lateral bracing and chords, and results in an increased toe pressure at the leeward edge. The longitudinal wind force is due to a torque at the main pier, due to normal wind pressure on the longer cantilever arm and half the suspended span resisted by the shorter anchor arm. This action results in equal and opposite reaction on the windward and leeward shoes on the main pier in a direction parallel to the longitudinal axis of the bridge. This longitudinal reaction is resisted by the friction between the steel castings and the masonry. As these castings are narrow in this direction, there is an overturning moment which is assumed to act on each casting individually and not on the entire base as a whole, which results in a very short lever

arm as compared with that used in determining the toe pressure from the transverse wind force acting at right angles. Certain allowances are made for the fact that the castings are riveted to the middle section, but even with this allowance there is a very appreciable increase in the pressure at the edges of the castings. Under such maximum conditions and assumptions, it is found that the maximum toe pressure amounts to 915 lbs. per sq. in. for all loads.

In all these calculations the following wind loads have been assumed: A wind load of 30 lbs. per sq. ft. of exposed surface of two trusses and 1½ times the eleva-

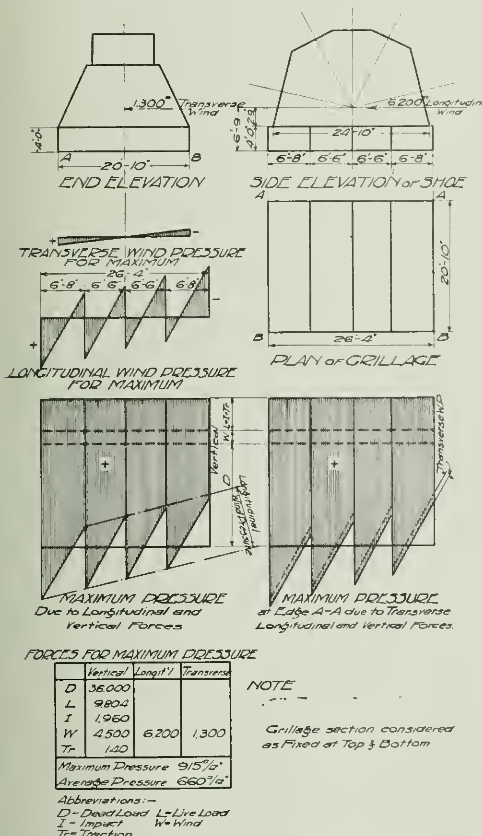


Fig. 6.—Diagram of Pressure Between Shoe and Masonry.

tion of the floor and 300 lbs. per lin. ft. on the exposed surface of a train covering the whole bridge applied 9 ft. above base of rail.

After the various parts of the shoe have been fabricated in the shop it is entirely assembled on concrete and steel skids and all field connections are reamed out in place or to a steel template. All loose parts are matchmarked with stencil and steel dies and all important centre lines chisel-marked on abutting faces. It is then taken down and the main sections re-assembled on the bed of the boring mill, and after having been accurately lined up with field level, transit and other special mechanical appliances, the five holes are bored at one setting. When this operation has been completed the shoe is again taken apart for shipment, the lower base being shipped in four sections, the middle in two main sections, and the top in one. When completed, each shoe weighs about 440 tons. The exterior faces of the middle section are covered with facia plates to give a finished appearance. These plates, as well as all diaphragms and top flange of castings, are provided with manholes, thus providing access to all parts of the shoe for riveting, inspection and painting. In order to prevent rain water settling in the interior, the shoe is partially filled with concrete which is sloped from the centre towards the sides, thus allowing all water to drain out through the holes in the facia plates.

In Fig. 1 is shown one of the four steel castings forming the lower story. It is being placed on the main pier. A thin grout is brushed over the masonry rest before the casting is put in place. The castings are assembled as shown in Fig. 2, which is a shop view showing erection on skids, and a start made on the erection of the middle section of the shoe. In Fig. 3 the second and third

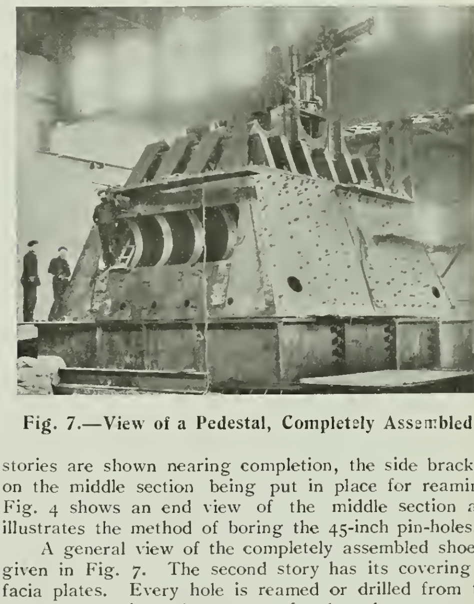


Fig. 7.—View of a Pedestal, Completely Assembled.

stories are shown nearing completion, the side brackets on the middle section being put in place for reaming. Fig. 4 shows an end view of the middle section and illustrates the method of boring the 45-inch pin-holes.

A general view of the completely assembled shoe is given in Fig. 7. The second story has its covering of facia plates. Every hole is reamed or drilled from the solid before being taken apart. It takes about 2 months to assemble, ream and bore this shoe in the shop, not including the time required for fabrication.

TORONTO HARBOR COMMISSIONERS TO CONTINUE WORK.

Although the early formation of ice on the bay will seriously interfere with their work along the waterfront, the Toronto Harbor Commissioners have made a careful survey of the territory under construction and are picking out the portions of the work that can be continued during the winter, in order to give employment to as many men as possible. A considerable portion of this work will consist of grading operations along the waterfront.

POROSITY OF BUILDING STONE.*

By D. G. Campbell, M.E.

THE quality of a building stone depends upon a number of factors, of which the following are more directly influenced by the porosity or water contents: strength, color, mechanical disintegration by climatic agencies, and rate of chemical decay.

Porosity in itself has small effect in determining relative qualities of building stones. That is, stones may vary in percentage of pore space from 0.5 up to 20 or 25%, and yet, other things being equal, these extremes may not show great variation in strength. The important point in connection with porosity, however, is the *size* of the individual pores.

Sandstones are the least compact of the stones used largely for building; and their porosity ranges up to 28% of the total volume, which is near the theoretical maximum. Such rock, when exposed to water, will absorb large quantities, and is equally capable of releasing it by evaporation. Moreover, it is difficult completely to fill the pores of such a stone with water. Stones of which the pores are very fine are slow to give up their contained water; if this be then expanded by frost, such stone is gradually weakened and disintegrated. It is by reason of this fact that sandstones may be quarried and laid in freezing weather without injury, whereas fine-grained stones are likely to be seriously injured by such treatment.

Limestones and marbles have much less pore space than sandstones, ranging from 1 up to as much as 10%; while in granite the pore space is less than 1%. In these stones, the pores are capillary or sub-capillary in size. Hence, such stones absorb but little water, and absorb it slowly; once in, it is equally hard to get out. When such a stone, saturated with water, is exposed to a hard frost, freezing expands the pores, and by breaking the union of the interlocked grains weakens the structure. Stones of such fine-pored character are injured by being quarried in cold weather, for the small percentage of "residual water" cannot then escape readily, and may repeatedly freeze and thaw in the stone, before evaporating, thus increasing the destructive effect.

This distinction applies only to true porosity; for if a stone be laminated, water filling the spaces between the bedding planes may do a great deal of damage. Hence the rapid disintegration of inferior, shaly sandstones under severe climatic conditions.

If limestone and marble be thoroughly seasoned before being used, their small ratio of porosity, and fine pores, are great advantages, contributing much to their durability (*Merrill*). This is because the sub-capillary pores absorb water with extreme slowness and difficulty. Hence, it would seem inadvisable to employ marble or compact limestone where it would be exposed to dampness combined with extremes of temperature. The following table (*Buckley*) gives the ranges in loss of strength suffered by various samples of building stones due to alternations of freezing and thawing for 35 days:

Loss of Strength by Freezing and Thawing.

Rock.	Orig. strength, lb. per sq. in.	Loss of strength, lb. per sq. in.	Loss, %
Granite	24,300	8,210	32
"	34,600	2,800	8
Limestone	30,680	13,675	44
"	8,100	570	7
Sandstone	4,170	1,950	46
"	5,330	930	17

*From the School of Mines Quarterly, Columbia University.

Life of Building Stone. (*Julien*).

Coarse brownstone	5 to 15	years
Fine laminated brownstone	20 to 50	"
Coarse fossiliferous limestone	20 to 40	"
Coarse dolomitic marble	40	"
Fine-grained marble	50 to 100	"
Granite	75 to 200	"
Quartzite	75 to 200	"

The color of a building stone may be due to one or all of three factors: inherent color of the minerals composing the rock; material that acts as a binder to hold the rock particles together; foreign matter and impurities. As examples of the first may be mentioned granites, gneisses, diorites, and the igneous rocks in general. In the second category come sandstones mainly, such as brownstone and red sandstones. In this case the cement that holds the sand particles together is an iron oxide. In the third group comes sandstones containing carbonaceous material, such as bluestone and the like; also igneous and metamorphic rocks, granite, limestone, and marble, containing small but noticeable amounts of iron carbonate or sulphides.

In the majority of the uses to which building stone is put, its color, and especially a small variation of color, is of slight importance. In factories and business blocks, breakwaters and retaining walls, for street paving and similar uses, color is immaterial. In ornamental buildings and residences, however, or for decorative and artistic uses, the permanence of color, and its uniformity, is of considerable importance. These features are largely influenced by the porosity of the stone, and the amount of water which, percolating through it, is able to dissolve mechanically or change chemically the color-producing ingredients. In the first class of rocks named above, change of color is effected only by alteration of the original minerals; this change may be complete after the lapse of long periods of time, but does not take place to any great extent in the ordinary life of a structure or piece of ornamental work.

In rocks of which the coloring is due to, or affected by, foreign matter and impurities, change of color or bleaching is accelerated by dampness and water content. The sedimentaries, sandstone for instance, frequently contain much carbonaceous material, which produces blue, brown, buff, cream, and other tints. These may fade or be washed out by percolating water. This change is, however, fairly uniform, usually, and is not serious enough to depreciate materially the value of the stone.

With such impurities as carbonate and sulphides of iron, the changes that occur are much more marked and objectionable. These impurities are gradually oxidized and deposited on the surface as irregular brown blotches, or as long dripping stains. Such result may be caused by gradual percolation of iron impurities in the cement and mortar used in construction, or in the material of the backwall. This objectionable condition is most frequently met in limestones and some marbles, occasionally in granite; it greatly reduces the value, if it does not completely prohibit a stone so affected from being used for ornamental purposes where it is exposed to moisture.

In such rocks as red sandstones and brownstone, there is much iron present in the form of oxide, serving as a cement to bind the particles of sand together. In this case no appreciable alteration of color is to be feared.

Besides the staining or bleaching produced by the oxidation of carbonate and sulphides of iron, a serious chemical effect is sometimes noted. This is due to the action of sulphurous and sulphuric acids released by this

decomposition, which dissolve calcium carbonate, and deposit an incrustation of calcium sulphate on the surface of the stone. If the quantity of such impurities be large, this may be a source of serious weakening. Artificial stones and concretes have been made from rock and slags carrying a large percentage of iron, and they were either seriously decomposed or completely disintegrated within a few years.

Again, when a stone is subject to the action of running water, or water under pressure, or especially both together, the calcium carbonate contents of the stone must be kept low. Water containing even slight amounts of carbon dioxide is an excellent solvent for that mineral, and not only wears it away on the surface, but, seeping through, is likely to honey-comb it so as to render it useless. An instance is noted where, in an English aqueduct, limestone was used in the construction, and in a few years the leakage through honey-combing had assumed serious proportions. Rocks composed of or bound together by siliceous material are not noticeably affected this way, as silica is insoluble in ordinary surface water.

The minerals composing the igneous rocks, as granite and rhyolite, are also subject to alteration and decay, but this proceeds so slowly that it is seldom apparent in the ordinary lifetime of a structure. Quartz and feldspar are the principal minerals. The former does not change at all, the latter very slowly under the influence of weather-weathering. The accessory minerals, mica, pyroxene, amphibole, and olivine sometimes accur in considerable proportions. These decay by oxidation and hydration much more rapidly and, especially if rich in iron, may cause trouble. If the stone contain many minute fractures, this weakening may be intensified, due to the fact that the products of alteration, serpentine, talc, chlorite, and the like, forming in thin, slippery layers and scales, make an excellent lubricant to aid any severe stress or shock in rupturing the stone. For this reason, stones rich in crystal micas, amphiboles, and pyroxenes, greenstone for instance, are usually viewed with disfavor.

To summarize the foregoing, it may be said that:

(1) The strongest and most enduring rocks have the least porosity; granites and gneisses less than 1%, limestones up to 10%, sandstones up to 20%. (This is ascribed to the comparative value of the binding material, silica, calcium carbonate, and iron oxide, respectively, the relative value of these as binding agents being (*Buckley*) in the order named.)

(2) Of unseasoned stones, those having large pores, as the sandstones, are less likely to be injured by freezing than those having sub-capillary pores.

(3) Water seeping through porous rocks usually bleaches and carries away color-forming impurities, and these may be deposited on the surface in the form of incrustations and stains.

(4) A porous stone possessing calcareous ingredients, on exposure to running water or to water under pressure, is likely soon to become honey-combed and to disintegrate.

(5) The accessory minerals of igneous rocks are also subject to slow alteration by oxidation and hydration, and if present in large quantities, may prove a source of weakness.

The MacArthur Concrete Pile & Foundation Company has sold the patent rights to drive the pedestal pile in Japan to the Oriental Compressol Company, of Tokio, Japan.

THE "FALL INCREASER" FOR LOW WATER FALLS.

By Clemens Herschel,

Civil and Hydraulic Engineer, New York City.

WITH the exhaustion of the available high falls for power purposes, the low falls will necessarily attract more attention than hitherto, from the builders of such plants. These last-named power sites frequently suffer materially from "back-water," in addition to the inroads made upon their annual output of power by low water.

A remedy for both of these power abatements lies, of course, in the use of auxiliary heat engines, but the use of these, means an increase of cost per kilowatt hour during the time of their running, and of the average cost per kilowatt hour during the year. Against low water inroads there is no other remedy; but against back-water power losses the use of the fall increaser offers a remedy that costs less in many cases than burning the fuel needed for generating the same power; that is to say, costs less than to run heat engines installed for the purpose of increasing the output of power during times of low water.

The fall increaser was invented in 1907, in the course of a competition for a power house design for Geneva, Switzerland, in which the competitors were especially invited to provide means for increasing the fall acting on the turbines during the times when, by reason of an overabundant water supply, the fall shall have been diminished. In the case named, the dam was to have consisted merely of "Stoney" gates; with the head water level nigh constant; so that the fall was expected to vary from 43 ft. down to 26 ft. This power house has not yet been commenced, but by the use of fall increasers, and by letting the freshet water pass through them, instead of allowing it to waste away under the Stoney gates, a suction could be exercised at the outlet of the turbine draft-tubes, that would keep the fall at 43 ft., and maintain the full power output some of the time of back-water, and at very nearly full power output, (when there is not enough freshet water to operate all of the fall increasers) the rest of the time.

Since 1907, the fall increaser has been tested at the Holyoke, Mass., Public Testing Flume; so that designs for it, and computations showing just what it will accomplish in any given case, can now be made with precision. A full account of these tests was published in the Harvard Engineering Journal, of June, 1908, and from this record it appears that the "operating water" (freshet water used) was as much as 14 sec.-ft.; the "water lifted" (turbine discharge) 7 sec.ft.; the "operating head" (natural head) was up to 14.35 ft.; the "head gained by the use of the fall increaser," up to 12.52 ft.; the fall increaser penstock, 16 inches in diameter; not mere "laboratory experiments," as anyone can see.

Similar experiments were made thereafter by one Dübi, in Zürich, Switzerland, the results published in book form, and they, naturally, have confirmed the results of the Holyoke tests. It thus only remains now to apply the fall increaser in actual practice.

That this has not already been done, need surprise no one. It is accounted for from the fact that 10 years or more are not infrequently needed to overcome the inertia, business jealousies, misconception of, and lack of appreciation with which new ideas of this sort are generally treated. It was thus with the Venturi water meter,

a first cousin of the fall increaser, 6,000 or 7,000 of which are now in use the world over, though it was 10 years before anyone would use it, except its inventor.

The fact that the fall increaser is only of limited application, and cannot practically be added to a plant already in operation (it must be built into the foundations of the power house) has also much to do with the delay, up to date, of its use in operation.

Its value at any mill site depends on the regime of the river; whether there is back-water, to a material extent, and during enough days in the year.

The situation must also be such as to permit of the conveyance of the freshet water to be utilized to the fall increaser inlets; no long head-race canal.

The writer of this has had cases in which the estimated additional first cost for putting in fall increasers would be returned in value of the *additional* kilowatt hours produced in one average year, or less; and from that the situation ranges up to periods and measurements of back-water so small that it does not pay to build fall increasers; even though first cost is paid but once (operation and maintenance are merely nominal), while the average additional kilowatt hours produced are produced and gained every year.

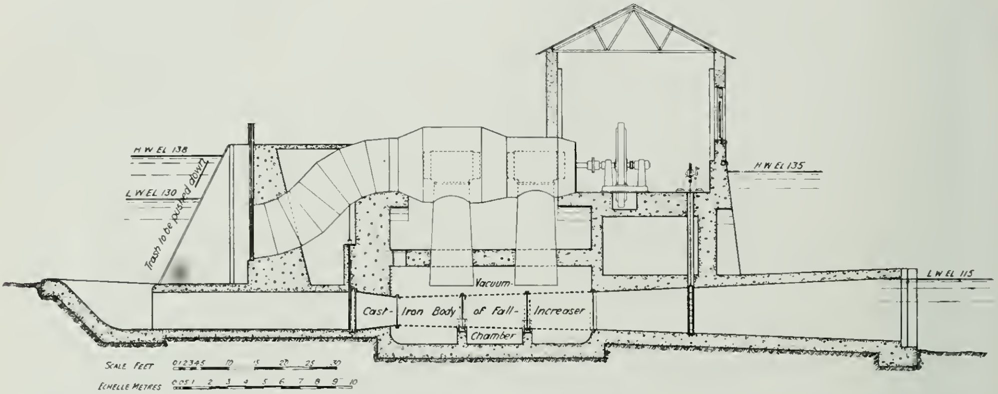
The money considerations involved are well shown by the results of some examinations made. In one case, for an estimated additional cost of $50,000 an additional 8⅓ million kilowatt hours, distributed during times of high water, (that is, when sorely needed), would be secured on the average, annually, forever. The net profit was estimated at not less than $23,000 per annum, forever. This plant has not yet been begun, and may be fitted with fall increasers when built.

In another case, fall increasers would produce, in an average year, 158 million kilowatt hours. They would keep the power practically constant throughout the back-water half of the year, instead of having it fall from some 250,000 h.p. down to about half that amount, during that period; (not considering the low-water half of the year). The additional cost entailed by building them would have been, as per estimate, one million dollars.

It might be thought, at first view, that fall increasers would have offered notable advantages at the Wasdell's Falls, Ont.,* power house, recently put in service, but impending improvements both in the Severn River and at Lake Simcoe outlet will do much to make the fall at this power house nigh constant throughout the year.

Incidentally fall increasers would greatly aid in keeping the racks clear of trash, which, when fall increasers are installed, needs only to be pushed down, and within range of their action, so as to pass through them; instead of having to be raked and lifted up and carried ashore. See the illustration, which is of an extreme case of back-water; only 3 ft. of fall left out of 12 ft. fall at ordinary water, on which account a siphon penstock is shown, to be kept clear of air at the summit by a small (an inch or two) fall increaser acting as an air exhauster.

Roughly and generally speaking, the "operating water" is double the turbine discharge, and the fall acting on the turbine is increased 50%, which increases the power given out by 80%. So long as back-water does not diminish the fall more than 33%, fall increasers will restore (from the fall and power then obtaining) the full, or normal, fall and power, and be of material benefit also, beyond the 33% mark.



Cross-section of a Power House, Showing Application of Fall Increaser. It Shows Also the Use of a Syphon Penstock. Note the Low Fall Remaining at Extreme High Water.

* See *The Canadian Engineer*, October 8, 1914, page 509, for full description of this development.

THE ROGER'S PASS TUNNEL IN B.C.

Since the publication of our last article descriptive of the progress already made in driving the 5-mile tunnel for the Canadian Pacific Railway under Roger's Pass at Glacier, B.C., the work has been advanced by the contractors, Foley, Welch & Stewart, with the greatest possible rapidity. On the east side the pioneer bore has been advanced considerably over a mile while the 8 x 11-ft. centre heading and the full tunnel section had been driven, on October 1st, a distance of 3,100 and 400 ft. respectively. At the western end the approach cut, requiring the excavation of 350,000 cubic yards, has been completed at that time, and the pioneer bore has been advanced over 2,000 ft. In the main tunnel portal a number of small headings have been worked for a considerable distance.

Editorial

THE "GLAGSESTEN" THEORY IN THE STORAGE OF IMPURE WATER.

In investigations which he has long had under way, Dr. A. C. Houston, director of water examination to the Metropolitan Water Board, of London, Eng., has become convinced that storage of impure water is not only demonstratively a process making for safety, but that a most important influence is at work, *viz.*, the devitalization of the undesirable bacteria, owing to their finding water a most unsuitable medium for their sustained activity. In his recent report, a section of which enlarges upon the value of storage in water purification, cognizance is given of such factors as the influence of glass on bacteria, and the effect of agglutination, sedimentation, sticking and enshrouding processes. With due consideration for the opinions of other writers on the theory that these factors really have an influence, he gives to it, for the sake of brevity, the name "glagsesten." The property of glass by which it imparts certain constituents to water, although relatively insoluble, is taken into consideration in conjunction with the storage of water in reservoirs, experiments in the latter confirming laboratory results with the former. It is concluded that the same principle of gradual devitalization is at work in both cases, although, perhaps, with a difference in degree.

The agglutination or clumping together of bacteria is readily explained by the apparent loss of vitality under conditions of storage. "If," Dr. Houston remarks, "we compare stored water with unstored water, we find that the former contains far fewer excremental bacteria than the latter, and the results on the average are not appreciably affected by preliminary violent shaking of the samples with lead shot sand and a mixture of shot and sand. Still it might be maintained that the shaking operations were not sufficiently drastic to break up the clumps, and if this is true the only difference between drinking raw river water and the same water after storage in reservoirs may conceivably be, that in the former case we ingest separated bacilli, and in the latter case clumps or balls of bacilli."

The sedimentation is, of course, a great factor in the importance of storage, and its influence is frequently quite noticeable in even less than twenty-four hours. As for particles in suspension tending to stick to various materials, it was demonstrated that shaking operations with shot and sand failed to explain all the observed facts relating to the storage of the impure water, indicating that sedimentation in itself was not wholly accountable. It was remarked that if the bacteria stick so closely as to be undetachable when subjected to the above process there is good ground to believe that they will stick so long to the sides and bottoms of reservoirs as to lose their vitality and die.

Discussing the enshrouding process, Dr. Houston does not appear to lay much importance upon it in his report. If, however, the enshrouding during the physical and chemical changes which occur under conditions of storage is so complete as to resist all shot and sand shaking operations, and so manifold that when a suitable nutrient medium is introduced no growth takes place, there would appear to be some ground for believing that ingestion of such a water would not be followed by any evil results.

The agglutination, sedimentation, sticking and enshrouding processes, concludes Dr. Houston, all make for the retention of pathogenic bacteria much longer in storage reservoirs than would otherwise be the case; so long, indeed, as perhaps to exceed the most extravagant estimate as to the length of time such microbes can live in water.

ENGINEERING ETHICS.

The Council of the Canadian Society of Civil Engineers has circulated among the members a ballot for the proposed amendment of several by-laws, to be considered at the next annual meeting of the Society. An important one among them is a proposed code of ethics, for adoption in place of the existing code. The regulations are as follows, and relate to every corporate member:—

(1) He shall act in all professional matters strictly in a fiduciary manner with regard to any clients whom he may advise and his charges to such clients shall constitute his only remuneration in connection with such work, except as provided by Clause 4.

(2) He shall not accept any trade commissions, discounts, allowances, or any indirect profit in connection with any work which he is engaged to design or superintend or with any professional business which may be entrusted to him.

(3) He shall not, while acting in a professional capacity, be at the same time, without disclosing the fact in writing to his clients, a director or member, or a shareholder in, or act as agent for, any contracting or manufacturing company or firm or business with which he may have occasion to deal on behalf of his clients or have any financial interest in such a business.

(4) He shall not receive directly or indirectly any royalty, gratuity or commission, on any patented or protected article or process used on work which he is carrying out for his clients, unless and until such royalty, gratuity or commission has been authorized in writing by those clients.

(5) He shall not improperly solicit professional work, either directly or by an agent nor shall he pay, by commission or otherwise, any person who may introduce clients to him.

(6) He shall not be the medium of payments made on his clients' behalf to any contractor or business firm (unless specially so requested by his clients) but shall only issue certificates or recommendations for payment by his clients.

Any alleged breach of these regulations or any alleged professional misconduct by a corporate member which may be brought before the Council, properly vouched for and supported by sufficient evidence, shall be investigated, and if proved, shall be dealt with by the Council, either by the expulsion of the offender from the Society or in such other manner as the Council may think fit.

NEW PUMPING EQUIPMENT AT BRACEBRIDGE, ONTARIO.

BRACEBRIDGE, Ont., has lately installed and put in operation some new electric-driven pumping equipment, to supply water at high pressure for fire service; or, alternatively, to double the quantity of water at half that high pressure. This system, known as the series-parallel arrangement of pumps, is one which is used quite frequently on municipal waterworks systems.

The equipment at Bracebridge consists of 2 single-stage Mather & Platt patent turbine pumps, each capable of pumping 800 Imp. gal. per min. against a total pressure head of 60 lb. The piping, as shown in the accompanying illustrations, is arranged so that these pumps may be run in parallel giving a total of 1,600 Imp. gal. per min. against a head of 60 lbs. They may otherwise be run in series, giving 800 Imp. gal. per min. against a head of 120 lbs. or they may be run singly, each giving 800 gal. against a head of 60 lbs.

Particular attention has been given to the testing of this equipment. Fig. 3 shows the equipment set up complete in the testing plant at Rockfield, Que., of the Canadian Allis-Chalmers, Limited, who manufactured the pumps. Curves giving the characteristics of the pumps at rated speed, as obtained in the test, are shown in Fig. 4.

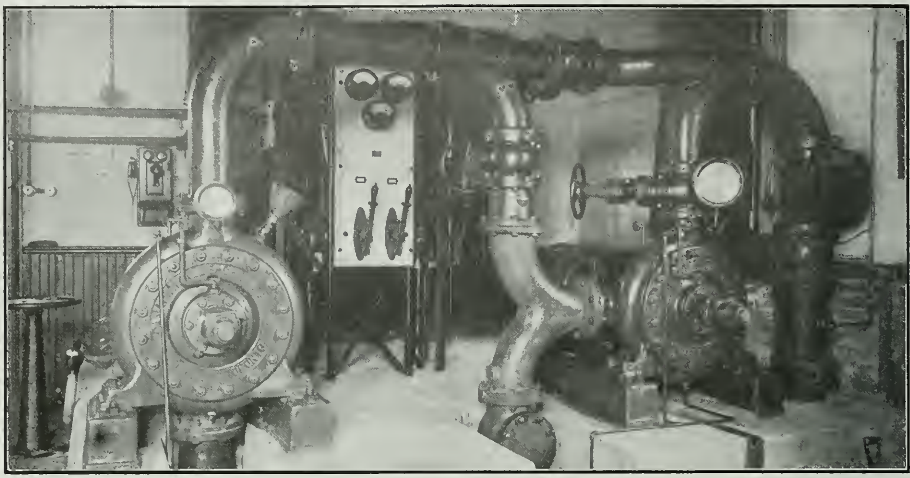


Fig. 1.—View of the New Installation at Bracebridge, Ont.

Fig. 2.—Four Fire Streams (one at a sharp inclination in the background) by Which the Pumps Were Loaded in the 24-hour Duration Test.

After installation, which is illustrated in Fig. 1, the pumps were given a 24-hour run under fire pressure conditions. They were loaded on 4 fire nozzles. (Fig. 2.) To obtain the correct load on these pumps, with rated speed, the pressure was adjusted to that corresponding to the rated quantity of water, as shown in Fig. 4. After this duration test was completed the units were put into service.

Each pump is driven by a direct connected C.G.E. squirrel-cage induction motor rated 60 h.p., 3-phase, 60 cycles, 2,300 volts, 1,800 r.p.m. At the end of the 24-hour run these motors showed a shut-down rise in temperature of 26° C. in the iron and 21° C. in the coils, both being the hottest spots found. From the pump curves it can be seen that 53 h.p. are required to drive each pump at rated capacity, head, and speed, so that not only is ample power provided to drive the pumps but the temperature rise in the motors shows liberal rating. The idea of having ample capacity in the motor is to take advantage of the overload characteristics of the pump. These pumps are equipped with diffusion guides on exit.

Referring to Fig. 5, the advantage of the use of diffusion guides can readily be seen, when the pump is for waterworks systems or similar service. These curves are taken from two other actual pumps, one with

and one without diffusion guides, and both rated 2,500 gal. per min., 880 r.p.m., and 180 ft. head.

The efficiency curves show a higher efficiency in the pump having diffusion guides, due to the better hydraulic conditions prevailing on account of having definite passages for the guidance of the water from the impeller and to the smaller losses in the smaller impeller required. On account of the smaller power required at no load and at full load by the pump with diffusion guides, it is evident that

Fig. 3.—Arrangement of Equipment, Pump-testing Plant.

its efficiency curve must be higher over the full range of the pump since the b.h.p. curves are nearly straight lines.

It will be noted that, with the pump not having diffusion guides, the point of maximum capacity is not very far beyond the point of maximum efficiency which is at rated capacity of the pump. The pump having diffusion guides, however, gives considerably greater capacity than that at which maximum efficiency occurs. So, by taking advantage of the overload guarantee of electric motors (25% for 2 hours) it can be seen that approximately 30% extra capacity can be obtained for two hours. This is valuable for heavy fire service and all the more valuable since the pressure only drops approximately 15 per cent. With a pump not having diffusion guides the pressure falls to zero on small overload demands, which would be serious if firemen coupled on a few extra lines of hose and opened them out too much. Furthermore, with this latter type, no advantage can be taken of the overload capacity of the electric motor.

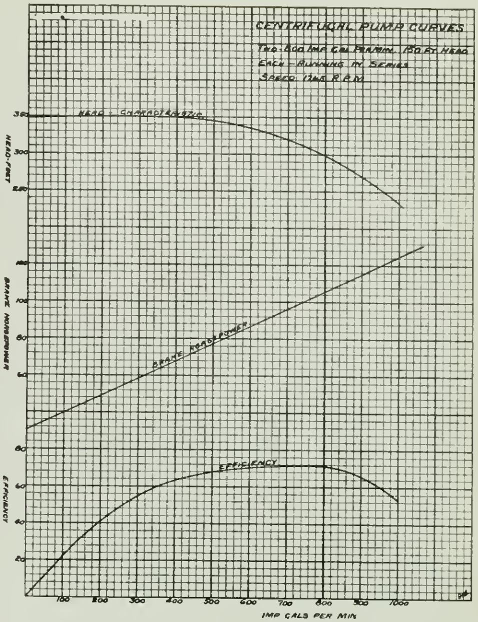


Fig. 4.—Characteristics of Two 800-gal. per min. Pumps Running in Series, 150 ft. Head, 1,765 r.p.m.

The characteristics of the diffusion guide pump were fully demonstrated at Bracebridge. The nozzles were removed and the discharge regulated by a valve. The discharge was increased above the rated capacity and the pressure held up as shown on the curve in Fig. 4. The equipment was intended for 4 fire streams and it was shown that nearly 7 could be obtained without a serious falling off in pressure, or overloading of the motor.

The overload relay on the motor was set for between 35 and 40% overload. On opening up the discharge wide the motors automatically tripped out. These conditions correspond to a break in the water mains and showed how the pressure was automatically removed which would prevent a big washout around the break in the water main. The overload relay can be arranged either to operate an alarm or trip the motor out or both.

Mr. W. C. Simmons, superintendent of the municipal systems at Bracebridge, laid out the equipment and put in the installation. The convenience with which his equipment may be operated is worthy of notice. The operator, standing in front of the switchboard, can start up both motors from that position and is able to watch his instruments while doing so. After the motors are started, by facing about, he has all the valves within reach and the gauges are mounted in front of him, so that he is able to see just exactly what is happening when opening the valves. It is easily possible to start everything from rest and have fire pressure on the mains within 30 seconds from the time the alarm is sent in.

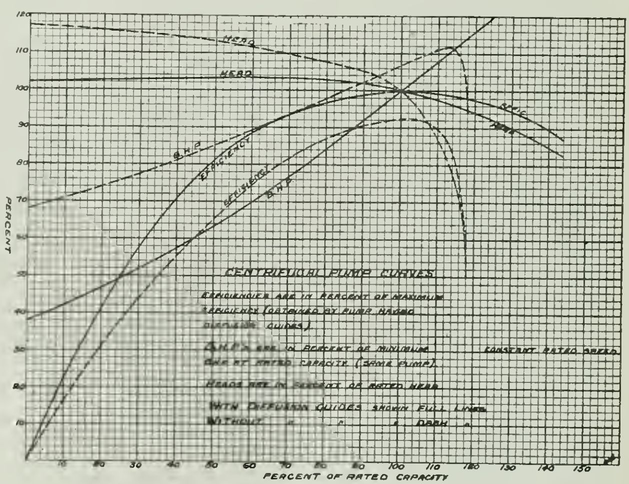


Fig. 5.—Effect of Diffusion Guides on the Characteristics of a Centrifugal Pump, as Shown by Actual Test.

HEAVY TRAFFIC ROADS.

By Henry G. Shirley,
Chief Engineer, State Roads Commission of Maryland.

IN selecting a type of surfacing for any particular road, the engineer not only has to study the amount and kind of traffic that daily passes over the road, but has to make a very comprehensive study of the amount and kind of traffic that will probably pass over the road in the future, by virtue of the development of the surrounding territory on account of the improved road.

The writer has made studies of roads where the traffic, before improvement, consisted of light vehicles and nothing heavier than 2-horse loads, but as soon as the road was reconstructed, the amount of traffic increased from 50 to 300%, and the loads from light 2-ton loads to 10 to 12-ton motor trucks, and 14 to 18-ton tractors. He also recalls constructing a section of road through a very sparsely settled section, and estimating that it would be quite a long time before the adjacent territory would be more thickly populated, and accordingly selected a soft local limestone for the metal surfacing, but which had sufficient strength and hardness to carry the traffic that was passing over the road at that time. Scarcely had the road been completed when several large tracts of woodland, not a great distance from the road, were cut down, and the lumber was transported on wagons, drawn by large traction engines with cleats, over the road to the railroad station. The effect of this heavy traffic on the soft limestone surface can be easily surmised.

Drainage.—Drainage of a road-bed that is required to carry heavy traffic, should be well taken care of by tile or other sub-surface drains, so as to render the subfoundation as dry and firm as possible. The maximum grade should not exceed a 6 per cent., and the alignment should be as straight as possible, with all sharp curves and bends eliminated. The width of the roadway and the width and thickness of the metal surfacing should be designed to meet the requirements of the present as well as the future traffic which it will have to accommodate, but the minimum width should not be less than 30 feet, nor the metal surfacing less than 18 feet. Broken stone or gravel make a fair foundation, but concrete is almost as cheap and is more preferable.

The thickness of macadam and gravel should not be less than 5 inches after rolling, nor more than 10 inches, while concrete should not be less than 4 inches, nor more than 8 inches, depending primarily upon the character of the soil of the sub-base, and the intensity and character of traffic it will have to sustain. In some cases where the loads are very heavy, but the number of loads small, it has been found economical to lay a strip of high-class and durable pavement in the middle of the road for a width of 9 to 14 feet, with a cheaper and less durable material on each side.

Before selecting the type of pavement to be used, a close and accurate census of the different kinds of traffic should be taken, a very thorough study made of the surrounding section, and an estimate made as to the possible increase of the different kinds of traffic, or the decrease of one kind and the large increase of the other. It is the opinion of the writer that in no other line of engineering should there be a larger factor of safety used than in estimating the amount, intensity, and kind of motor and self-propelled traffic that will pass over our improved roads in the near future. The great change in the character of traffic developed in the past five years, is but a small index to what can be expected in the next five years to come.

The types of pavements used on heavy traffic roads should be selected as to their fitness to stand the kind and intensity of the traffic that will travel them. Roads in the outlying districts, where horse-drawn traffic comprises the larger percentage, should be constructed of macadam with a light surface treatment. Concrete will also be found serviceable and desirable. Where motor traffic is in the majority, bituminous macadam or concrete will give good results. Near the centres of population, where the traffic is mixed and heavy, concrete, bituminous concrete, asphalt or vitrified brick will prove the most economical. Where the heavy traffic is concentrated, brick, asphalt or stone block are the most suitable.

There can be given no hard and set rule for selecting the type of construction that should be used on a given section of road to carry a known traffic. For local conditions, the availability of materials, etc., play such an important part in the selection of the type of surfacing in any locality, that each individual case must be worked out on its own merits.

The following method of selecting a type of surfacing to carry an estimated traffic, however, will prove fairly accurate where a study can be made and the maintenance cost can be had of roads constructed and maintained under similar conditions:

Where the annual cost of maintenance of a less durable type of road surfacing will exceed the annual cost of maintenance of a more durable type of surfacing, plus 4 per cent. on the excess cost of the more durable type over the less durable type, the more durable type should be used, and vice versa.

The maintenance on heavy traffic roads should be continuous and thorough—never allowing the surface to remain broken any length of time, but as soon as the slightest defect or indication of failure appears, it should be speedily repaired.

LARGE PROJECTED HYDRO-ELECTRIC STATION IN NORWAY.

The proposed exploitation of the water-power in the Take Falls, with the co-operation of the Norwegian State, is one of the largest undertakings in the country. The first stage is the building of a power-station with a capacity of 125,000 h.p., which can be obtained simply by the regulation of the Totak, by retaining the water of the Totak during the high-water season and using the power of the Vinje waters without any regulation. The plan is based upon an English Company contracting for about 100,000 h.p. for a period of 30 years, with the option of a further 20 years at $7.25 per h.p. per annum, the energy to be supplied as alternate current of some 10,000 volts, the factories in question to be erected within a distance of 100 kilometres from the power-station. The Take waters represent one of Norway's largest and best water-power streams. By regulating the Totak and the Vinje waters a capacity of 250,000 h.p. is confidently reckoned upon, and of this 140,000 h.p. will come from the Totak after regulation. Of this the Hyllands Fall represents 15,000 h.p. The exploitation of either the Totak and the Vinje is not expected to offer any difficulties whatever from a technical point of view, and the cost can, it is confidently asserted, be kept at a comparatively low figure, the existing roads for transport, for one thing, being adequate. The cost of the finished power-station for the first 125,000 h.p. is calculated at $26.80 per electric h.p., and the next 125,000 h.p. will naturally come out somewhat cheaper.

ONTARIO'S MINERAL PRODUCTION IN 1913.

The following table gives a summary of the mineral production of the Province of Ontario for the year 1913, as presented in the statistical review by Thos. W. Gibson, Deputy Minister of Mines, in the 23rd annual report of the Bureau of Mines, 1914.

Table I.—Mineral Production of Ontario, 1913.

Product.	Quantity.	Value.
Metallic:		
Gold .... ozs.	220,837	$ 4,558,518
Silver .... ozs.	29,724,931	16,579,094
Copper .... tons	12,941	1,840,492
Nickel .... tons	24,838	5,237,477
Iron ore .... tons	195,937	424,072
Pig iron .... tons	648,899	8,719,892
Cobalt oxide, etc. ..... lbs.	(a) 1,188,526	420,386
Nickel do ..... lbs.	(b) 232,255	13,326
	....	$37,793,257
Less Ontario iron ore (132,708 tons) smelted into pig iron	....	285,322
Net metallic production.	....	$37,507,935
Non-metallic:		
Arsenic, refined .... lbs.	(c) 2,450,758	64,146
Brick, common .... No.	408,808,000	3,452,352
Tile drain .... No.	16,935,000	292,767
Brick, paving, etc. ..... No.	18,547,000	243,119
Brick, pressed .... No.	81,238,000	919,741
Stone, building and crushed	....	1,137,153
Calcium carbide ...... tons	2,052	123,100
Cement, Portland ..... bbl.	3,802,321	4,105,455
Corundum .... tons	1,177	137,036
Feldspar .... tons	18,615	67,142
Graphite, refined ..... tons	1,788	93,054
Gypsum .... tons	40,581	92,627
Iron pyrites .... tons	71,620	171,687
Lime .... bush.	2,300,991	390,600
Mica .... tons	386	55,264
Natural gas.. million cu. ft.	12,516	2,362,021
Peat .... tons	500	1,750
Petroleum ...... Imp. gal.	7,915,761	398,051
Pottery	....	52,875
Quartz .... tons	54,320	130,860
Salt .... tons	96,799	474,372
Sewer pipe	....	600,297
Sand and gravel ... cu. yd.	425,978	233,567
Talc, ground .... tons	20,738	125,340
Non-metallic production	....	$15,724,376
Add metallic production.	....	37,507,935
Total	....	$53,232,311

(a) The estimated quantity of metallic cobalt contained in the ores raised from the silver-cobalt mines was 377 tons; this includes the quantity converted into oxide.

(b) The estimated quantity of metallic nickel contained in the silver-cobalt ores was 821 tons, which is included in the quantity converted into oxide.

(c) The ores extracted from the Cobalt silver mines are estimated to have contained 3,633 tons of arsenic, which includes the quantity of refined arsenic given in the table.

Coast to Coast

St. John, N.B.—Dredging operations at Salmonier have been completed. A channel, 940 ft. long has been cut into the main basin at Little Harbor to avoid danger from running ice in the winter.

Vancouver, B.C.—Mr. J. G. Bury, vice-president of the C.P.R., while in the city last week, announced that the Kettle Valley Railway from Midway to Merritt, providing an alternative scenic route by way of the Crow's Nest Pass, will be in operation by next June.

Edmonton, Alta.—When the season closes about 345 miles of grading and steel will have been laid upon the Edmonton, Dunvegan and British Columbia, and upon the Alberta and Great Waterways Railways this year. The J. D. McArthur Construction Company are the contractors for the work.

Hamilton, Ont.—The National Gas Company states that it will lay 7½ miles of pipe before January 1st, as required by its franchise. Tenders for trenching and laying pipelines from Black Heath to Hamilton, a distance of 16 miles, and also for the above length of line within the city limits are now being advertised.

Toronto, Ont.—A large steel buoy steamer, 164½ ft. in length, 30 ft. breadth, and 13 ft. depth, built for the department of marine and fisheries, was launched at the Polson Iron Works on November 7th. It is equipped with triple expansion jet-condensing engines of 900 h.p. capacity, and will be provided with all modern electrical equipment, including search light, etc.

Vancouver, B.C.—Oil burning locomotives will be used, according to statements made in an official interview, by the Grand Trunk Pacific on its transcontinental route. The company is preparing contracts for large developments, and oil storage facilities are receiving considerable attention. The terminals at Prince George, Endako, Smithers and Pacific, noted in these columns last week, are among the divisional points where storages will be established.

Toronto, Ont.—To relieve transportation difficulties in Ward 7, the city will proceed immediately with the construction of a car line extending west on Bloor Street from Dundas Street to Quebec Avenue, at an approximate cost of $125,000. Permanent track will not be laid this fall, but a temporary line will be constructed without delay, and will be in operation before the end of the year. It will be a single track provided with turn-out switches. The Street Railway Company has offered to operate the line charging the city 20c. per car mile and allowing single fare rates to passengers using both the proposed line and the company's service.

Montreal, Que.—Grading has been completed on the Canadian Northern Railway from Montreal to the harbor of Vancouver, and it is expected that this length will be completely railed before the beginning of the new year. Two gaps each of about 50 miles in length are waiting for steel in British Columbia, and track-laying is going on at the rate of about two miles per day. There are also three bridges to be completed, viz., at the Back River, at the crossing of the Chat River above Ottawa, and a third in British Columbia. The substructures for the three have been finished, and the superstructures will be completed in about a month. The company's big undertaking at Mount Royal has progressed very favorably since the last announcement in these columns. Over a mile of tunnel has been excavated to full cross section and about 600 ft. of lining has been put in.

CANADIAN SOCIETY OF CIVIL ENGINEERS, REGULAR MEETING, NOV. 5th, 1914.

The President, Mr. M. J. Butler, C.M.G., occupied the chair. The speaker of the evening was Professor H. E. T. Haultain, M. Can. Soc. C.E., of the University of Toronto. The opening paper was a description of an integrating machine for weighing materials in motion. Mr. Haultain described a device which has been in use in the gas works in Toronto since the beginning of this year, whereby coal is weighed without interruption as it passes over the conveyer system. The explanation was illustrated by models and actual working parts.

The automatic weigher consists essentially of a portion of depressible track over which the conveyer runs. The centre of the depressible track is connected to a series of weighing levers which in turn by their motion impart a movement to an integrator. The integrator travels on a plane circular disk which is caused to revolve by the motion of the conveyer itself. The combination of the rotation of the disk and the side movement of the integrator thereon enables a card to be drawn showing the weight passed over the machine. The introduction of batteries renders it possible to record the weights on an ordinary dial.

Following the curtain raiser Professor Haultain read a paper entitled "The Wielder of the Weapon." This unique and masterly address was followed by an interesting discussion taken part in by Messrs. M. J. Butler, R. A. Ross, Professor Porter, Walter J. Francis, Charles E. Fraser, R. F. Uniacke, Julian C. Smith, and J. M. R. Fairbairn.

PERSONAL.

W. K. MOWATT has been appointed hydro-electric inspector for the city of Brampton.

A. W. THORNE, of St. John, N.B., has been appointed provisional secretary of the New Brunswick Union of Municipalities during the illness of Mr. J. W. McCready.

A. E. PICKERING, formerly manager of the Tagona Light and Power Co., Sault Ste. Marie, is manager for the city of the same concern now that it is taken over by the city.

C. M. WATERMAN, Canadian manager of the Eugene Dietzgen Co., Limited, has returned to Toronto after an extended visit to the firm's head office and factory at Chicago, Ill.

C. A. ELLIS, for several years resident engineer at Winnipeg for the Dominion Bridge Co., has been appointed assistant professor of civil engineering at the University of Illinois.

A. S. FARMER, formerly superintendent in Moncton, N.B., of the natural gas department of the Moncton Tramways Electricity and Gas Co., has resigned to accept a similar position in Oklahoma.

JOHN S. BATES has been appointed superintendent of the Dominion Forest Products Laboratories of McGill University to succeed Mr. A. G. McIntyre, who resigned to take charge of a new paper mill at Bathurst, N.B. Mr. Bates is a graduate of Acadia University in arts and science, and of Columbia University in chemical engineering.

The Canadian Northern Railway is developing a 50,000-h.p. plant from the Sumallo and Nicaloon Rivers, which will be employed in operating the Canadian Northern trains from Port Mann to the False Creek terminals at Vancouver, B.C.

OBITUARY.

Last week the death occurred of Mr. Donald McDermid, Toronto. For many years he had been engaged in railroad construction work. On the mountain division of the C.P.R. he constructed a number of bridges and snow sheds. He was also associated with Mackenzie, Mann & Co. on the C.N.R. At one time he was in partnership with Hon. J. S. Hendrie, now Lieutenant-Governor of Ontario, in the firm of McDermid and Hendrie.

The death has been announced of Mr. Keith Ross Cameron, whose connection with railway building in Ontario is well known. Mr. Cameron was engaged in railway work for some time with the Grand Trunk Railway, and later with the Lake Erie and Detroit River Railway.

BACK COPIES WANTED.

The following back copies of *The Canadian Engineer* are required by one of our Canadian libraries to complete sets for binding:—January 1st, 1907; February 1st, 1907; March 1st, 1907; January 29th, 1909; January 8th, 1912; October 31st, 1912, and January 2nd, 1913. If any of our readers can supply one or more of these copies, we will be glad to extend his subscription one month for each copy returned to this office.

COMING MEETINGS.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

WASHINGTON STATE GOOD ROADS ASSOCIATION.—Convention to be held at Spokane, Wash., November 18th, 19th, and 20th. Secretary, M. D. Lechey, Alaska Building, Seattle, Wash.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.

AMERICAN ROAD BUILDERS ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.—Annual Convention to be held at the King Edward Hotel in Toronto, January 26, 27, and 28, 1915. Secretary, G. C. Keith, 32 Colborne Street, Toronto.

EIGHTH CHICAGO CEMENT SHOW.—To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.

AMERICAN WATERWORKS ASSOCIATION. — The 35th annual convention, to be held in Cincinnati, Ohio, May 10th to 14th, 1915. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—Annual meeting to be held at the Iowa State College, Ames, Iowa, June 22nd to 25th, 1915. Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Volume 27. Toronto, November 19, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

STREET IMPROVEMENT IN FREDERICTON, N.B.

NOTES ON THE COMBINED CURB AND GUTTER, DESCRIBING THE METHODS OF LAYING AS ADOPTED IN THAT CITY—DATA ON LABOR AND MATERIALS.

MANY styles of curbs are in use to-day, with varied opinions associated with each. The combined curb and gutter type has been adopted by the city of Fredericton, N.B., and the past season has seen some interesting pieces of construction there. The following information has been furnished us by Mr. R. R. Stevenson, B.Sc., who, the office of city engineer being vacant at the time, did the engineering work for the city. The methods, forms and materials used are described below, and some valuable cost data is added.

Laying Out the Combined Curb and Gutter.—Fig. 1 shows a plan of a small section of the city showing Regent St., just laid with concrete curb and gutter, and the cross streets (which can be picked out from the plan as they are named). As in nearly every city, there are instances where old residents have encroached on the streets due to slackness on the part of the city in the past years, in holding them to the proper street lines. This has necessitated building the combined curb and gutter to fit the existing house lines of to-day.

This entails the plotting of a plan and deciding the best location for the combined curb and gutter. As can be seen from the plan, it was impossible to get a straight line the entire length of the street, hence the engineers decided that the next best plan would be two straight lines with the smallest possible deviation in direction. The best place to make the turn, it was decided, was at Charlotte St. A ship's spike was driven at the exact middle of the street at Brunswick and another in the middle of Charlotte and Regent Sts.; another spike was driven at Aberdeen St., exactly in the middle of the roadway. The bend between these two straight lines was hardly noticeable, there being only an angle of 19 ft. between them. At each street crossing the curbs were carried around the corner so that if the curbs of the cross streets were later built the existing ones would be in a position to connect without the necessity of extra work. At the proposed extensions of cross streets the combined curb and gutter was carried only far enough to allow for the turn around the corner and a space left.

Method of Alignment.—The line could not be laid out in the middle of the road due to the interference of the traffic. It was offset 25 ft. on each side, which brought it on the asphalt sidewalk. The line was then laid down

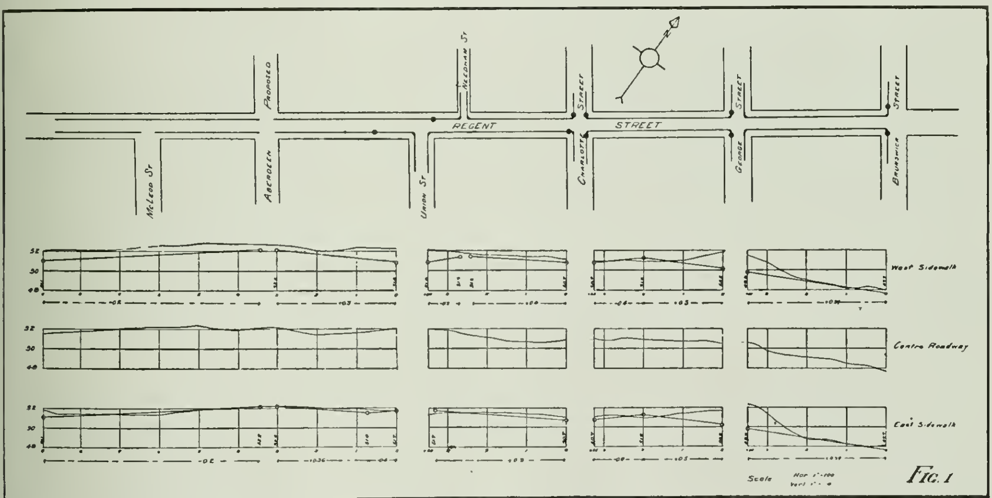


FIG. 1

Regent St., Fredericton, N.B., Showing Alignment Grades, Levels, Profiles, etc., Required.

at 25-ft. intervals by means of tar-paper tins and 8d. nails, the nails being driven through the tins and into the asphalt sidewalk on the exact 25-ft. line. This gave the contractor a good chance to place his forms on the exact line of the back of the curb, there being no possible chance to be out in distances less than 25 ft. Instead of measuring every 25 ft., a batter post was often put in every 200 ft. and a cord stretched between them. The line was hardly necessary every 25 ft., but in putting in the grade plugs, which are necessary every 25 ft., the extra alignment points proved very handy.

After the points were in, the contractor simply had to measure 10 ft. from them, which would give him the location of the front of the curb, it being decided by the city that a 30-ft. roadway would be allowed. This gave 18 ft. of sidewalk from the front of the curb to the house line, the streets being 66 ft. wide.

The alignment of the curb being established, the next thing was to determine the grades and elevations of the combined curb and gutter and to establish them. In Fig. 1 is shown the profiles on the different blocks on Regent St., there being 3 profiles of each block in the determination of the grades and elevations, one on each side of the street and one in the middle of the roadway. The level readings were taken every 25 ft., and after being plotted up, the grades, as shown in Fig. 1, were determined upon. The only parts that needed much judgment were at George St. and the block from Needam out.

At George St., as seen from the profile, there was a sudden rise which looked strange, whereas the rest of the town was level. It was decided that it would be best to cut this hill down, making a gradual slope which would be much easier on traffic than the sudden rise, a gradual 0.6% slope was put in from Brunswick to George St. After the road was completed it was seen that this was by far the best thing that could be done both from general appearance and the ease with which big loads were handled. From Union St. out one side of the road was much higher than the other, so that the combined curb and gutter had to be put in so that it fitted both in the best way possible.

Catch-basins were put in where necessary and are marked in Fig. 1 by small circles. These were built with loose rock with only a sand bottom, and each was therefore more of a cesspool than a catch-basin, the water draining out through the loose rock and the sediment being held in the basin.

Construction of Curb and Gutter.—The combined curb and gutter was constructed by J. M. Chappell, Esq., of the City of Fredericton, N.B., and his method of constructing is well worthy of comment, he having a system of forms which cuts down the cost of construction materially, as will be seen.

Fig. 2 is a drawing of a section taken through the curb and also giving a plan and elevation of one 8-ft. block showing another joining on each end. This shows the expansion joints which, in past years, has been a great trouble to get in correctly and cleanly. First, the trench has to be dug out to a depth of 30 in. below the top of the grade plugs. In this trench is placed about 16 in. of broken stone or field stone and tamped tightly into place, forming the foundation and underdrainage for the curb and gutter. Next, the cinders; these are simply coal clinkers and provide an even bed or "cush" for the concrete. (Gravel or sand would answer the purpose just as well but would make a difference in the cost, the gravel costing $1.25 per yard and the coal clinkers 50 cents.)

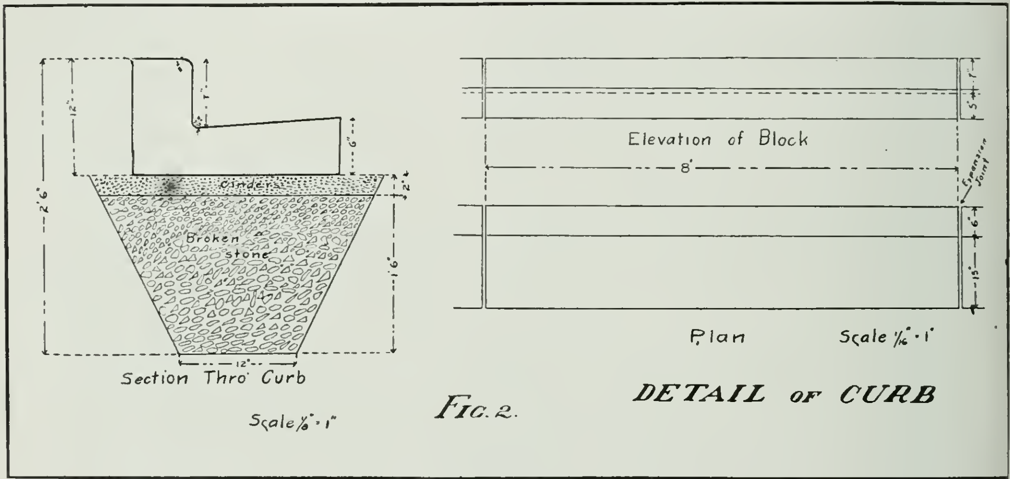


FIG. 2.

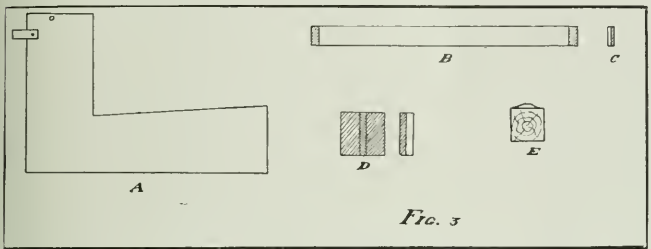
Plan, Elevation and Cross-section of an 8-ft. Length of Curb.

The form for the back of the curb is now put in place. This should be the most carefully done of any of the form-placing as on this all the rest of the form-placing hinges. If it is correctly done, all of the forms must, as a matter of course, come to their place. This form is a 2-in. plank 12 in. wide and of any convenient length. It is placed on the line of the back of the curb and just so that the top of the plank is level with the grade plugs. This brings the cinder "cush" just up to the bottom of the plank. It is then nailed and braced into place.

Next the steel forms that make the expansion joints are put into place. These are made of ⅛-in. steel and are the shape of the section of the curb. They are the same size as the curb and gutter except that they are just a little longer to supply a hold to enable them to be

pulled out easily after the concrete has set. A small piece of steel is riveted on the side 12 in. from the bottom, or at just the height of the curb. In this way the plate stays in place, as shown by *A* of Fig. 3. One of these is placed every 8 ft. in the length of the curb.

The next step must be made with planks which must be made in a special manner and cut to fit. These are 2-in. dressed lumber with one edge bevelled, as shown in *B* and *C* of Fig. 3. These planks are in lengths of 7 ft. 11 in., and the ends of each plank are cut half through 3 in. from the end and this small piece cut out. *D* of Fig. 3 is the connecting piece between the plank. It is cut into 7-in. lengths, as shown. The boards forming the front of the curb are now placed on the steel forms, being held apart by means of blocks 6 in. square, as shown in *E* of Fig. 3. The ends of the plank are kept just an inch apart to allow the part *D* to fit in. This is put in place and makes the front form solid by the joint. Clamps are now put on and the back and front forms are clamped together, the wooden block only allowing them to be clamped to their proper distance—6 in. This is shown in Fig. 4.



Details of Expansion Joint Forms.

The form for the edge of the gutter must be put in place. This is made of plank 6 in. wide and cut to any suitable length. The plank is placed against the gutter part of the steel form with the top of the plank just level with the top of the gutter part of the steel form. Earth is then filled in to keep the plank in place. The forms are now complete and ready for the concrete, as shown in *B* of Fig. 4.

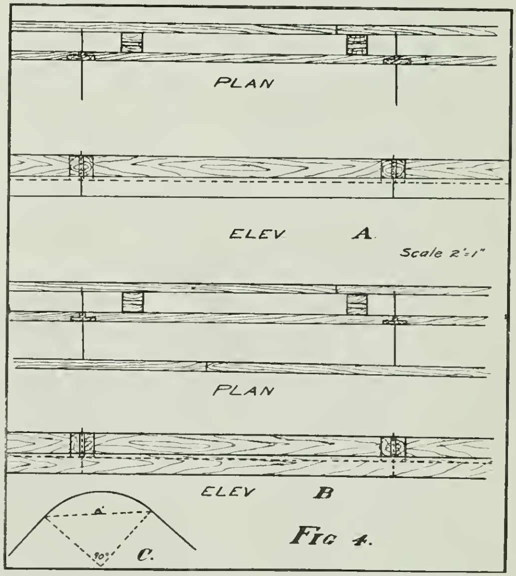
Mixing.—As one crew is mixing the concrete and placing the forms, another can be sprinkling the old work, backfilling, etc.

The mixing is done with a small hand-turned mixer capable of mixing 1/10 yard of concrete in one mix. This answered the purpose very well, mixing quite fast enough to keep a small crew of men busy. The mixer should be on wheels, to be wheeled easily from one part of the work to another, so that, while one man turns the machine, two shovel into the mixer and one man with a wheelbarrow may easily handle all the concrete being mixed.

Corners.—Taking the combined curb and gutter around the corners should be one of the most carefully done parts of the work, as an even, symmetrical corner adds more to the general appearance of the work than the ordinary workman would imagine. The general public is much more liable to notice a small error in the corner turn than a large one in the block length of the curb and gutter. A design of the turn is given in *C* of Fig. 4. The form for the back of the curb is the usual plank used on the block cut to a length of 8 ft. The steel forms are put in at the ends of this plank and the ordinary 7-ft. 11-in. plank put in to make the tangent to the curve. The form for the front of the curb on the turn is made of some pliable lumber, ½-in. thick, and is bent to the required circle. If necessary, it is braced into place until the concrete has taken its initial set. The forms are then taken off and the concrete is patched up at any place that the forms have not left in good shape.

Finishing.—In the finishing up of the work the trowel is used very sparingly on the concrete, the work being floated with wooden floaters and only where it is necessary to round the edges is the former used. It has been found by experience that a steel trowel tends to bring the cement in the mixture to the top, thus making a very rich mix on the surface, which, with age, will make hair cracks and cause checking. After the forms are taken off any rough parts in the concrete may be gone over with a concrete brick mixed in the proportion of 1 : 2, which fills up the small voids, takes off any rough edges and gives a general finished appearance to the work.

Cost Data.—The work in Fredericton was handled by one foreman with a crew of 11 men, arranged as follows: One man turned the mixer and dumped it; two men placed the cement and gravel in the mixer while one man wheeled the concrete from the mixer to the forms, thus making a total of 4 men required to do the mixing. One man placed and tamped the concrete in the forms, putting in the top dressing as the concrete was placed; two men were required to place the forms, leaving them ready for the placing of the concrete, while two more dug the trench and placed the broken rock and cinders. One experienced man was needed to do the finishing and floating while the rest of the workmen were common laborers without much knowledge of concrete.



Details of Forms.

Materials.—*Cement*: The cement used was Portland in bags, the work requiring 20 bags per 100 ft. of combined curb and gutter. The price of the cement, taking out the refund on the bags, was 50 cents per bag.

Gravel.—The fine aggregate and coarse aggregate was combined in the form of river gravel, the work requiring about 5.6 cu. yds. per 100 ft. of combined curb and gutter. The gravel cost on the work $1.25 per yard.

Broken Stone: The stone for the foundation and underdrainage was ordinary building stone broken to the proper size. The work required 8.7 cu. yds. per 100 ft. of combined curb and gutter. This stone cost $1.25 landed on the work.

Cinders, Forms and Labor: The cinders used were ordinary hard coal clinkers, costing 50 cents per yard landed on the work; 100 ft. of curbing requiring 1.4 cu. yd.

The forms used were made of spruce planks and, roughly speaking, 3,000 ft. B.M. was used, the forms being used over and over again. This lumber cost $30 per M.

In this work 11 men were used, there being a foreman at $3 per day and 10 laborers at $2, making a total of $23 per day.

Following is the cost data given in tabulated form. Table I. gives the amounts of the different materials used and the number of feet of curb constructed every 6 days in the 41 days needed to finish the work. Table II. gives the total costs of the different materials and the total wages paid.

The total amount constructed was 4,032 feet, while the total cost was $2,192.30, making the cost per lineal foot 54 cents.

Table I.—Materials.

Days.	Cement used, bbls.	Gravel used, yds.	Cinders used, yds.	Broken stone used, yds.	Curb constructed, ft.	Men per day.
1-6	15.6	17.3	4.8	27.8	320	11
7-12	30.2	31.3	8.7	50.5	580	11
13-18	31.7	32.9	9.6	53.1	610	11
19-24	33.8	35.1	9.7	56.6	650	11
25-30	37.4	38.9	10.8	62.6	720	11
31-36	39.0	40.5	11.2	65.3	750	11
37-41	20.9	21.7	8.0	35.0	402	11

Table II.—Costs.

	Amount.	Cost.	Total.
Cement	208.6 bbls.	$ 2.00	$ 417.20
Gravel	217.7 yds.	1.25	272.10
Cinders	62.8 yds.	.50	31.40
Broken stone..	350.9 yds.	1.25	438.60
Forms	3,000' B.M.	30.00	90.00
Men	11 per day	23.00 per day	943.00
Total cost			$2,192.30

The first railway in Shantung was commenced in 1899. It extends from the port of Tsingtau to Tsinanfu, the capital of the province (a distance of 395 kilometers), and has been built by the Shantung Railway Company, which was founded in 1898 for the purpose of taking over the railway concession granted to Germany by the treaty of 1898. The capital of this German-Chinese company is 54 million marks, in 54,000 fully paid-up shares. The company is registered at Berlin, where is also its head office. It is a single line throughout, of a 1.535-metre, or normal gauge; but sufficient land to build a double line is provided for.

THE IRON AND STEEL SITUATION.

Regarding the iron and steel market in the United States as it stood at the beginning of the month, the "Steel and Metal Digest" observes that it was not in a state of stagnation but of complete prostration. The closing fortnight of October witnessed an absence of buying, of specifying on contracts, and of general interest in the market on the part not only of buyers but even of sellers, that certainly has never before been witnessed in the history of the steel trade, now some quarter century old. In earlier years, when wrought iron was the controlling factor, instead of steel, some parallel to present conditions may have existed for periods in 1878, long remembered as a phenomenally bad year although, naturally enough perhaps, followed the next year by one of the greatest booms, if not the greatest, in all iron and steel market history. Taking up the great industrial depression of the eighteen nineties, picking out the worst of those years, 1896, and the worst period in that year, one does not find a parallel to what has occurred, or rather has failed to occur, in the past fortnight. The reference to 1878 having been a phenomenally bad year, immediately followed by a boom year, furnishes no basis in itself for predicting much better things next year, though the reference contains a suggestion. There was a similar boom in 1899, but while 1879 was preceded by a year in which pig iron production was less than in three much earlier years, 1872, 1873 and 1874, the boom year 1899 was immediately preceded by two years which while dull each broke all previous records for pig iron production. It was a sudden change from 1878 to 1879, but the change from 1896 to 1899 was slow.

The rate of steel production at the beginning of November is approximately 40% of the capacity. Only in very exceptional instances, as when many mills have been closed over Christmas holidays, or when there has been a sudden but largely temporarily closing by reason of a panic, has the percentage rate fallen so low. The steel mills have never run for more than three consecutive months at a lower rate than 50% of capacity.

There is no definitely established price situation. Prices are not a consideration. Usually in dull periods they are an issue, and a very important one, but at present the buyers have nothing like a definite position. They are waiting for a chance to act, not a chance to buy at certain prices. Indeed, with many products it is a question where the market price really stands. There is actually not enough business offered, in some instances, to disclose at what prices mills would be willing to sell. The great majority of producers have nominal asking prices, which they would be only too glad to be tempted to cut in an effort to start business moving.

COST OF SUPERVISION OF HIGHWAY CONSTRUCTION.

The following statement shows the annual cost of supervision of construction of highways by the State highway department of Ohio in percentage of the amounts expended by the State in such construction:—

	Per cent.
1914	4.03
1912 and 1913	5.71
1911 and 1912	6.18
1910 and 1911	6.40
1909 and 1910	5.39
1908 and 1909	5.43
1907 and 1908	5.28
1906 and 1907	7.55

THE MAXIMUM POWER CAPACITY OF A PIPE LINE.

By T. H. Hogg, C.E., Toronto.

In hydro-electric power plant design it is sometimes interesting to know the maximum possible power output of a prospective development which is to have a long feeder conduit. This information is desirable in fixing the diameter of the pipe to be used. To do this accurately entails a study of the economics of the design with reference to the value of the power consumed in friction, the cost of the pipe, transportation conditions, speed-regulation, etc.

The electrical horse-power to be obtained from a given installation is obtained from the formula:

$$P = \frac{62.5\, Q\, h\, E_t\, E_g}{550}$$

where P = electrical horse-power; Q = quantity of water in cu. ft. per sec.; h = net head; E_t = efficiency of turbine; and E_g = efficiency of generator.

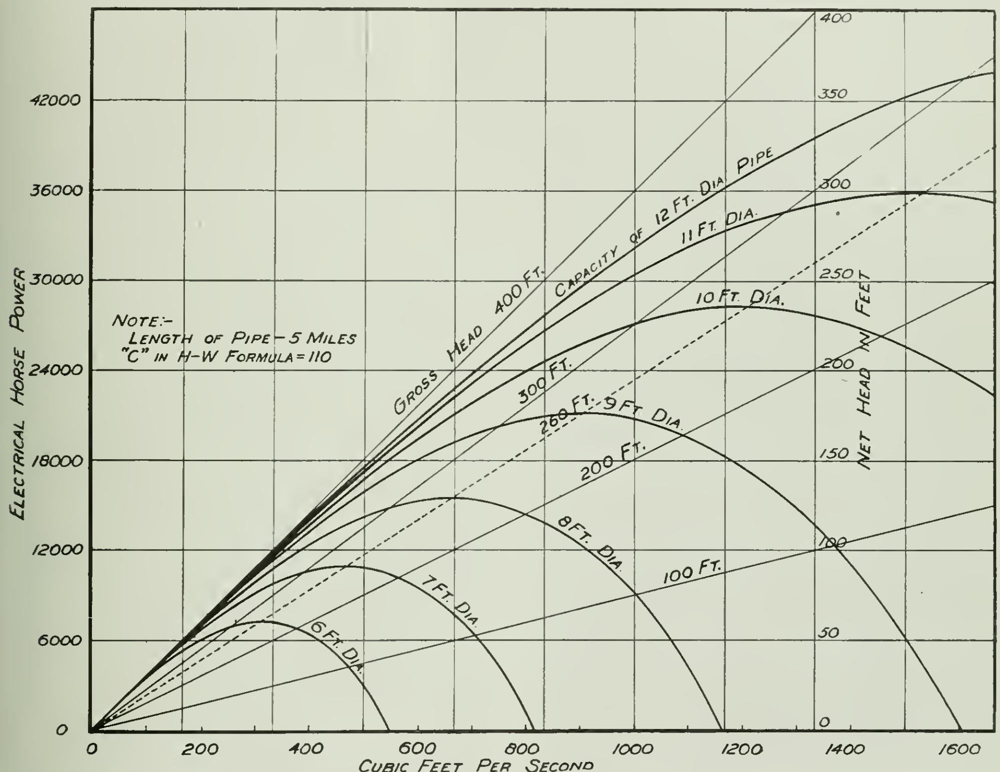
This may be written in the form $P = n\,Q\,h$, where n is a constant, and equal to $\frac{62.5\, E_t\, E_g}{550}$; or $P = n\,A\,v\,h$, where A = area of conduit, and v = velocity in ft. per sec.

Now, $h = H - c\,v^m$, where H = gross head and $c\,v^m = h_f$, or the friction loss in feet. Therefore, $P = n\,A\,v\,h = n\,A\,v\,(H - c\,v^m) = n\,A\,v\,h - n\,A\,c\,v^{m+1}$. In order to get the maximum value of this expression, differentiate with respect to v and equate to zero.

$$\frac{dP}{dv} = n\,A\,H - (m+1)\,n\,A\,c\,v^m = o$$

Therefore $H = (m+1)\,c\,v^m$.

The value of m is a constant usually taken, as a result of experiment, at some value between 1.8 and 2.



Maximum Power Capacities of Conduits of Various Diameters.

Hazen and Williams, in their tables for the losses in pipes, use the value of m equal to 1.85.

Substituting, $H = 2.85\,c\,v^{1.85}$. Now $c\,v^{1.85} = h_f$.

Therefore $c\,v^{1.85} = h_f = \frac{H}{2.85} = \frac{\text{gross head}}{2.85}$. Or, for maximum power in a conduit, the friction loss is equal to the gross head divided by 2.85. If we assume that the losses vary as the square of the velocity this expression will become the gross head divided by 3.

If we use velocities higher than those sufficient to give these losses, the power will decrease as the velocity is increased, until, at the limit, all the available energy in the water is being used up by friction; or when $c\,v^{1.85} = h_f = H$.

The accompanying chart illustrates this very well, as a short study will show. It will be noted that the

maximum power for each diameter of pipe falls on the head line for 260 feet, or when the loss of head is $\frac{400}{2.85}$ equal to 140 feet.

It will be appreciated, of course, that no conduit would ever be designed for this maximum condition, as the losses of head are too large for economical operation unless water economy is of no object. In any case, conditions at this point are far too unstable to permit of any speed regulation. Probably, in an actual case, the maximum velocity to be used will give losses about one-third of that for maximum power.

REINFORCING PAVEMENT FOUNDATIONS.

The determination of the use of reinforcement in concrete pavement will depend upon the type of foundation and width of pavement. A paper by C. D. France, before the Indiana Engineering Society, gives some useful information respecting it. The writer states that reinforcement may be used in either single or two-course work, and is particularly designed to care for slight settlement of fills, and to guard against contraction cracks developing where the pavement is wide. In any road where a new fill of over 2 feet is made, and the material used is other than sand or gravel, the pavement should be reinforced, no matter what the width of the road. No amount of compacting by roller or puddling can effectively settle such a fill, so that no further movement of the foundation is probable after the placing of the pavement.

The type of reinforcement which is most economical in price and handling is wire fabric. The weight of material to use in this fabric has been the subject of much discussion and, although it may be well sometimes to consider each specific case, in general it may be said that reinforcing metal running parallel to the centre line of the pavement should have a cross-sectional area of 0.038 inches per foot of pavement width, and a cross-sectional area perpendicular to the centre line of the pavement of at least 0.049 inches per foot of pavement length. Reinforcing has been advocated in two-course work where it is spread upon the still plastic base, which, being slightly undulating, insures that no line of cleavage can possibly develop between the two courses, and, in addition, imparts greater strength and security to the pavement. In single-course work, reinforcing is placed about 3 inches from the surface.

PROGRESS ON SOOKE LAKE AQUEDUCT.

In *The Canadian Engineer* for July 23rd, 1914, the essential features were published relative to the project under way at Victoria to supply 16,000,000 gallons per day through 27.3 miles of reinforced concrete gravity pipe line and 10 miles of 36-inch steel pressure pipe, the supply to come from the Sooke Lake watershed. The work has progressed very favorably since that time. On October 8th the steel pressure main was successfully tested under a maximum pressure of 200 lbs. per square inch. Construction on the 42-inch concrete pipe line is well under way. It is to be noted that little success was achieved in the steam treatment used to hasten the setting of the pipe in the molds at first, and many of the sections had to be culled. Later on, however, the improvement of the steaming process gave much better results, and has proved a decided advantage in the construction of the pipe, and well worthy of note.

GRADES AND EXCAVATIONS.*

By A. D. Williams,
Chief Road Engineer, State of West Virginia.

IN the past two or three years stress has been laid upon the subject of permanent roads. Many articles have been written bearing upon the various kinds of surfaces, but the ever-important subject of grade and excavation has received only passing notice. Yet the only permanent thing about a road is its grade and location. The various kinds of surface will yield to the actions of the elements and pass the march of time, but the road once established will become more fixed as the years go by, adding improvements and new property lines to bind it firmly in place. This makes more important the engineering subject of our roads. The establishment of grades and location should be given the greatest consideration.

Minimum Grade.—The principal factor entering into the determination of a minimum grade is the question of sufficient drainage. Except on fills over 2 feet the minimum grade should not be less than 3/10 of 1% and preferably not less than 5/10 of 1%.

Maximum Grade.—There are a number of factors that enter into the maximum grade, but, before attempting to locate any road or to establish any grade the engineer should make a thorough study of the territory to be developed by the proposed road, giving due consideration to the following points:

(1) What will be the present and future demands of the territory adjacent to the proposed improvement;

(2) What are the possible developments in the territory from an industrial, agricultural, educational and social standpoint;

(3) What part will the proposed road be of a general system of roads reaching to other communities and what will be the effect of the improvement on other sections;

(4) The nature of traffic that the road will be called upon to take care of, making due allowance for development, considering the present and future tonnage;

(5) The general direction in which the greatest amount of tonnage will be transported, the class of tonnage and the time necessary to move it in order to make it the most marketable;

(6) The direction in which the ascending grade will be in comparison with the possible traffic demands;

(7) The maximum load that a horse can pull based upon the length of grade and the time required to make the trip, from the standpoint of the horse and the time necessary to get the best results for the kind of material the country will produce;

(8) Consideration should always be given to climatic conditions and to the season that the roads will be required to take care of the heaviest traffic, as well as a study of the foothold for horse-drawn vehicles. The possible amount of frozen or icy weather should be noted in determining a maximum grade;

(9) The class of material over which the road is to be made and the cost of construction on the longer distance compared with the steeper grade and shorter distance have a certain bearing upon the subject, because the most important subject in connection with the cost of roads on grades is that of maintenance which increases very rapidly with the increase of grade. Roughly speaking, the destructive effect of violent and periodical storms

*From a paper read at Fourth American Road Congress, Atlanta, Ga., November 9 to 14, 1914.

is four times as great on a 5% as on a level ground, and nine times as severe on a 10% as on level grade. Thus if no other factors were to be considered on earth roads alone the cost of upkeep in a very few years would justify the elimination of bad grades;

(10) The condition of the right-of-way and the possible chances for disposition of water and drainage are factors of much importance when considering the maximum grade, because on steeper grades the increasing velocity demands more drainage and greater skill in handling the water, which, if kept on or near the road, will soon destroy it;

(11) The consideration of a grade from the ascension is not the only angle of approach in the location of highway grades because important items enter into the descending grade that should be given as much, if not more, consideration than the ascending direction;

(12) A grade should not be steeper than a horse can descend safely in a trot;

(13) A grade should not be steeper than a team can safely descend with a load that it can handle for ten hours under normal conditions, exerting its normal tractive force;

(14) The amount of time necessary to descend a grade should be considered, making due allowance for the maximum speed that can safely be used on that grade;

(15) The highway engineer of to-day must remember that as time passes the motor traffic requirements of the public highway will be more and more exacting. Experiments as to gasoline consumption and its efficiency on difficult grades and materials are now being conducted near Uniontown, Pennsylvania, by Mr. R. O. Gill, Experimental Engineer for the Chalmers Motor Company of Detroit, Mich. In this connection we have but little data. Some recent experiments made by Mr. H. Kerr Thomas and Mr. D. Ferguson, of Buffalo, N.Y., for the Pierce-Arrow Motor Company, show that the class and kind of surface exert more influence upon the motor-driven truck than the percentage of grade and that it requires practically the same tractive force on a 1% grade in sand and loose stone to handle the same load as it does on a 27% grade on concrete, asphalt, new brick and first-class macadam. But observations lead to the conclusion that grades of any length exceeding 5 or 6% are not as satisfactory and as economical as lighter grades for motor traffic owing to the increased hazard, increased consumption of gasoline, and loss of power due to the resistance to gravity. Observation further concludes that in frozen or icy weather motor traffic is extremely hazardous on grades exceeding 10%, and entirely unsafe on grades exceeding 16%;

(16) Grades crossing a summit should merge into each other by some form of vertical curve. The writer has been accustomed to using the following formula which proves satisfactory and practicable. Take the summit grade at e and a grade point 100 feet on each side or any other desirable distance and by use of either one of the following formulas find the elevation at f, which will be half-way between e and g, then by use of the formula find the offset from the tangent at each of the ordinates. This subtracted from the elevation of the ordinate will give the true elevation of the grade.

By reference to Gillespie, whose work contains about all we have upon tractive power of a horse, which embraces the experiments of Sir John McNeil, Sir Henry Parnell, and Mr. Cayffier, some of whose works are quoted by nearly every writer, we find that a horse traveling at the rate of 2½ miles per hour can exert 10% of his weight, and traveling at the rate of 4 miles per hour, can exert 6% of his weight. These observations prior to 1850 and just before the advent of the steam road into our field of engineering embrace about all the experiments we have, excepting the work of Mr. E. B. McCormick, of Kansas State Agricultural College, and the works of Prof. J. H. Waters, of the University of Missouri, and other work by Mr. McCormick is now being done for the Office of Public Roads, at Washington. The writer's personal observations have shown that a horse for a limited period can exert ¼, and sometimes even greater percentage of his weight, this depending in a measure upon the kind of shoes on the horse and the foothold on the grade. A horse on a road material that offers safe footing can be safely trotted down a 5% grade, but cannot be trotted down this heavy a grade for any great length of time without injury by "jamming" or "stoving" him up. Therefore, the ruling grade should not exceed 5%, if for a horse-drawn vehicle over which speed must be made on the descending grade, because the average horse in walking down a grade will not make over 4 miles per hour, while he will trot 12 miles per hour; thus, from this standpoint, we can double the distance of the road and increase the time 33⅓%. The speed of 12 miles

Picking, 5c.; Plowing, 2c.; Steam Plowing, 1.5c. per cu. yd. Hauling by wagon, approximately 35c. per cu. yd.
Hauling by trucks and tram, 14c. per cu. yd.
Comparative cost per cubic yard for moving earth with

Distances hauled, feet.	Wheel-barrow.	Drag or slide scraper.	No. 1 wheel scraper.	No. 2 wheel scraper.	1-horse cart.	Wagon.	Tractor and trucks.	Grader.	Casting over bank.
100	$0.057	$0.090	$0.100	$0.100	$0.056	$0.095	$0.080	$0.022	
200	0.114	0.135	0.130	0.125	0.068	0.103	0.080		
300	0.170	0.180	0.160	0.150	0.080	0.111	0.080		
400	0.230	0.225	0.190	0.175	0.090	0.119	0.080		
500	0.285	0.270	0.220	0.200	0.101	0.127	0.080		
600	0.342	0.315	0.250	0.225	0.112	0.135	0.080		
800	0.457	0.405	0.310	0.275	0.135	0.151	0.080		
1000	0.570	0.495	0.370	0.325	0.160	0.167	0.090		
1500	0.857	0.720	0.520	0.450	0.214	0.207	0.090		
2000	1.143	0.945	0.670	0.575	0.271	0.247	0.100		
3000	1.713	1.395	0.970	0.825	0.388	0.327	0.100		
4000	2.280	1.845	1.270	1.075	0.500	0.407	0.100		
Loading by Hand.									
	$.050	$0.010	$0.010	$0.010	$0.130	$0.130			$0.100
Loading by Steam Shovel.									
					$0.060	$0.060			$0.060

per hour should not be undertaken down a grade of more than 3% with a vehicle bearing any kind of a load. In ascending a 5% grade the capacity of the team is about 4/10 of its capacity on level ground and about ¼ of its capacity on 10% grade, on a loading for the same tractive exertion, but a point here that should not be forgotten is that for a short duration a horse can exert from 25 to 40% of his weight, thus doubling and quadrupling its normal tractive force and in this connection it is often better economy, considering the financial condition of the community, to put in a short piece of 6 and even 7% grade, than to expend a large amount of money in making an exhaustive and expensive cut, especially so if the cut must be made at the expense of development in some other part of the community. One thing that should be borne in mind is that each year's development of our country makes the chances for changing of grades and their elimination less possible, and that while the improvement of the surface of a road increases its tractive efficiency about 200% on level ground it only increases about ¼ for a horse-drawn vehicle on a 10% grade, thus money expended in decreasing the grade within a reasonable amount of distance is the best possible investment.

Then, with these conclusions drawn and a decision as to the kind of surface that will possibly be placed upon the road at some future time, we are in position to determine what should be the maximum grade.

Methods and Costs of Grading and Excavating.—This is a machine age and wherever grading can be done by machinery it is usually more economical. The following table, based upon figures taken from different pieces of work, is approximately correct to a wage scale of 15 cents per hour and capable supervision.

By a glance at the figures it will be seen that at 22 cents per yd., or at the same cost for any given ratio, the ratio cost distances are: for wheelbarrow, 200 ft.; drag scraper, 400 ft.; wheel scrapers, 500 and 600 ft.; 1-horse cart, 1,500 ft.; wagon, 1,800 ft., while tractor and truck on track do not reach the amount within one mile. The cost of grading depends materially upon the class of material, the location and the management of the operation.

As to methods, the writer would suggest the use of machinery wherever possible under competent supervision and under proper direction. On work that is light and on which machinery can be employed the work should be done by day labor. On heavier work and large quantities the writer would recommend contracting, and to the contractor a systematic organization of his work so as to get the most efficient service from his men and equipment. There are volumes written covering the subject of cost data in heavier work, but my experience in highway work leads to the conclusion that there are many elements entering into the cost of highway construction that are often overlooked when comparing this class of work with heavier work. One point of deficiency that has been noticeable and should be emphasized here is the lack of organization in highway construction in the various sections of the country. In many instances 50% of the cost could be saved by an adequate organization.

Economical Considerations.—The economical phases of highways and highway construction are many, and call for more than the available space. The history of highways and highway economics can be divided into three periods: The Roman or Ancient Road; the Telford and Macadam period, extending from 1750 to about 1840, and our modern or twentieth century awakening. The Roman road, with its 3 feet of stone, was reduced about one-half in the days of Telford and Macadam, and now, with modern machinery, we are constructing macadamized roads at costs ranging from $1,000 to $4,000 per mile, concrete from $7,500 to $12,000 per mile, and brick from $9,000 to $20,000 per mile. It should be borne in mind that the cross-section of a road should be so as to permit the greater portion of the work to be done by machinery on ground where machinery can be operated, and that an extra width of the road on hillsides increases the cost. A road on hillsides should not be wider than is needed to care for the traffic. In country districts a 9-ft. concrete bituminous or brick or a 10-ft. macadam with 5 ft. of earth on each berm will meet all the requirements at much less cost.

On ground free from roots and stone, where a road machine can be used the material can be moved at a cost of less than 5 cents per yard, and on hillside grading, where the work is casting, a small steam shovel is an economical machine to use. With this should go a drilling outfit and attachments so it can be operated with the same power.

In conclusion, the most economical thing a community can do is to improve its roads so as to serve all its demands, and to do this it should employ a competent highway engineer to make a careful study of the needs of the territory, its financial ability to construct and maintain a road and to locate and superintend the construction of their road for them. When the road is constructed a competent patrolman should be placed on it to continually keep up the maintenance and repairs.

DOMINION GOVERNMENT ELEVATOR FOR VANCOUVER.

The Department of Public Works, Ottawa, purposes constructing a grain elevator with a capacity of 1,500,000 bushels on the government dock on Burrard Inlet, Vancouver. A site 578 x 352 feet with an additional wharfage 800 x 300 feet is being prepared.

The foundations of the plant are to be concrete piers carried down to concrete footings which shall rest on natural bedrock.

The buildings will be of reinforced concrete and will consist of a working house, track shed, storage house, sacking plant, transformer building, and conveyer galleries to handle bulk grain and grain in sacks from the elevator to the dock.

The whole of the work is to be furnished complete and ready for operation to receive, clean, and ship bulk and sacked grain on or before November 1, 1915.

The elevator will complete the chain of terminal and interior elevators erected by the government throughout the west from Port Arthur to the Pacific. The Vancouver elevator is intended to take care of the grain which will move westward from the prairie provinces for shipment via the Panama Canal.

Tenders close on November 30th.

In view of the fact that the war had cut off the supply of blocks formerly secured by England from Northern Europe, British Columbia millmen have forwarded to London samples of blocks made from British Columbia fir.

Division engineers of the New York State Highway Department have been directed in submitting estimates for construction to include hereafter an approximation of the number of working days required to complete each contract. This, it is expected, will enable the Highway Department to specify time limits on contracts more accurately, as the local engineers who work up the field notes are unquestionably in a better position to weigh carefully the elements which enter into the building of a piece of road than the office force are.

MUNICIPAL IMPROVEMENTS IN ALBERTA TOWNS AND CITIES.

SOME very interesting figures relating to the installation in 1913 of waterworks, sewerage and sewage disposal works in the Province of Alberta are presented in the report of R. B. Owens, B.A., B.E., Provincial Sanitary Engineer, in the recently issued report for last year of the Alberta Department of Agriculture. The following is a detailed list of new works or extensions, with estimated costs:

Waterworks.

Gleichen: Completion ....$	4,851.00
Blairmore: System	15,000.00
Tofield: System	14,000.00
Redcliff: Extension	120,000.00
Bassano: System	17,800.00
Athabasca Landing: System	127,440.00
Edmonton: Extension	311,600.00
Lethbridge: Extension	34,636.00
Medicine Hat: Waterworks plant	75,000.00
Extension	225,000.00
Extension	193,410.00
Calgary: Extension	378,000.00
Extension	643,200.00
Edson: System	90,000.00
Coronation: System	40,000.00
Total estimated cost for water....	$2,289,937.00

Sewerage and Sewage Disposal Works.

Bassano: Sewage disposal system ....$	12,000.00
Extensions, sewerage system	1,500.00
Athabasca Landing: Sewerage system	70,000.00
Edmonton: Extension to sewerage system..	569,500.00
Lethbridge: Extension to sewerage system.	92,500.00
Extension to sewerage system	72,000.00
Extension to storm sewerage system..	13,595.00
Extension to sanitary sewerage system	18,627.00
Medicine Hat: Extension to sewerage system	144,484.00
Main trunk sewer outlet and pumping station	105,000.00
System of storm sewer	50,000.00
Calgary: Extensions to sewerage system...	348,750.00
Extension to sewerage system	43,731.00
Extension to sewerage system........	30,628.00
Edson: Sewerage and sewage disposal system	55,000.00
Total estimated cost of sewerage and sewage disposal works	$1,627,315.00
Total estimated cost of waterworks, sewerage and sewage disposal works	$3,917,252.00

The present standing of the various cities and towns in Alberta, with respect to municipal improvements, with the exception of roads, streets, etc., is as follows:

Edmonton.—Population, 73,000; water supply, m.o. (municipally owned), pumped from Saskatchewan River; 2 intakes consisting of steel pipes with screens and cribbing protection. Water mains, 128.6 miles; 9,275 house services; 5,738 houses without services; 1,477 stopvalves; 648 hydrants, and 14 fountains. Daily consumption, 5,000,000 gal. Mechanical filtration plant (Roberts). Samples tested every other day in provincial laboratory.

Sewerage system, partly combined and partly separate; 117 miles of sewers, ventilated at man holes and vertical soil stacks; 9,275 house services; 8 gravity outfalls to be reduced to 3. Part of the sewage treated by sedimentation.

There are two refuse destructors, a Heenan and Froud on the south side and a Decarie on the north.

The first town down stream is Fort Saskatchewan, 20 miles distant by river.

Calgary.—Pop., 80,000; water supply, m.o. Source, by gravity from Elbow River and by pumping from Bow River, both chlorinated. Bow River intake is a compound flume of reinforced concrete leading to pumps 600 ft. distant. Elbow River intake is a timber crib at the river bank. Water mains, 184 miles; 12,000 house services, and 400 houses supplied from 50 standpipes; 1,002 hydrants. Daily consumption, 11,750,000 gal. Samples tested regularly in municipal laboratory.

Sewerage system partly combined and partly separate; 188 miles of sewers, ventilated at every house service; 7,940 house services; 1,010 catch basin connections; 7 gravity outfalls into Bow and Elbow Rivers east of city, to be reduced by intercepting sewers built or under construction, to one main outfall. No part of sewerage treated. Plans under way for treatment system; packing plants and other trades deliver waste into sewers without preliminary treatment.

There are two refuse destructors, both Heenan and Froud.

Municipal gas supply, natural; obtained from Bow Island.

Medicine Hat.—Pop., 14,000; water supply, m.o.; source, South Saskatchewan River, by low-lift pumps to filters and high-lift pumps to reservoir and standpipe, with capacities 2,750,000 and 500,000 gal. respectively. Intake is a 36-inch cast iron pipe with concrete pier and a 20-ft. diameter well on the river bank. Water mains, 31 miles; 2,350 house services; 240 stop valves; 170 hydrants, and 6 fountains. Daily consumption, 3,000,000 gal. Mechanical filtration plant (New York Continental Jewell). Samples tested regularly in Medical Health Officer's laboratory.

Sewerage system, separate plan; 20.3 miles sanitary sewers ventilated through man-holes 94 yards apart, and vertical soil stacks; 3.2 miles storm sewers; 1,000 house services; 96 catch basin connections; three outfalls into South Saskatchewan River, each with a pumping station for discharge during high water. Daily discharge, over 1,000,000 gal. Sewage is not treated.

The first town down stream is Saskatoon, about 600 miles distant by river.

Municipal gas supply, natural, 1,050 B.t.u.; 38 miles of high and low pressure gas mains; 2,265 house services.

Lethbridge.—Pop., 11,000; water supply, m.o. Source, by pumping from Belly River; 38 miles of water mains; 2,000 house services and 120 houses without services. Daily consumption, 1,500,000 gal.; not filtered.

The first town up stream is Macleod, 30 miles distant by river; down stream, Diamond City, 6 miles distant.

Sewerage system, separate plan. One storm sewer with 100 catch basin connections. Two gravity outfalls; sewage treated in sedimentation tanks and filters.

Gas supply, natural; supplied by private company from Bow Island.

Macleod.—Pop., 2,500; water supply, m.o. Source, Old Man River; pumped by steam; 2 intakes, 16-inch wood pipe 700 ft. long and 20-inch wood pipe 2,300 ft. long, respectively. Water mains, 8.5 miles; 425 house services; 152 stop valves and 55 hydrants. Daily consumption, 450,000 gal.; mechanical filtration plant (Roberts).

Sewerage system, combined plan; 6 miles sewers with man holes 100 yards apart; 225 house services, catch

basins trapped; 1 gravity outfall into Old Man River; disposal works to be constructed.

Wetaskiwin.—Pop., 3,500; water supply, m.o. Source, 3 wells each 250 ft. deep; pumped by compressed air to underground concrete reservoir, thence to elevated water tower with 227,000 gal. capacity. Supply ample. Water mains, 6.25 miles; 268 house services; 300 houses without services; 65 stop valves and 51 hydrants. Daily consumption, 100,000 gal.

Sewerage system, combined plan; 6.4 miles of city sewers and 3.5 of outfall sewers; ventilated at man holes and tops of house service stacks; 267 house services and 17 catch basin connections; 1 gravity outfall 3½ miles from city. Daily discharge, 120,000 gal.; treated in sedimentation tanks and effluent disinfected.

Municipal gas supply, natural, 975 B.t.u.

Red Deer.—Pop., 2,500; water supply, m.o. Source, Red Deer River by pumping; 1 intake, an 18-inch gravity flow pipe to two wells 18 ft. diam. and 20 ft. deep. Water mains, 7.25 miles; 305 house services; 102 stop valves; 34 hydrants, and 2 fountains. Daily capacity, 400,000 gal., filtered through 2 ft. of sand cylinders in each well.

Sewerage system, combined plan; 4.76 miles of sewers, ventilated at man holes 130 yards apart. 215 house services; 45 catch basin connections, untrapped; 1 gravity outfall into Red Deer River.

Redcliff.—Pop., 3,200; water supply, m.o. Source, South Saskatchewan River by pumping. Water mains, 15.5 miles; 308 house services, 108 houses without services; 106 stop valves, 33 hydrants. Daily consumption, 100,000 gal.; natural filtration.

Gas supply, natural, supplied by private company; 16 miles of mains and 430 house services.

Camrose.—Pop., 3,100; water supply, m.o. Source, 3 wells 130 ft. deep; pumped by compressed air to reservoir, thence by centrifugal pumps to water tower. Water mains, 2.5 miles; 90 house services; 23 stop valves, and 28 hydrants. Daily consumption, 37,500 gal.

Sewerage system, separate plan; 3 miles sewers and 90 house services; 1 gravity outfall discharging 33,000 gal. per day; treated on earth beds and effluent, disinfected by bleaching powder.

Athabasca.—Pop., 2,000; water supply, m.o. Source, Athabasca River by pumping; 1 intake, two 8-inch lines steel pipe to suction well; 4 miles water mains. No house services, system used entirely for fire protection. 22 stop valves and 24 hydrants.

Bassano.—Pop., 2,200; water supply, m.o. Source, Bow River, by pumping to a stand pipe; 1 tunnel intake, water gravatating to deep well. Water mains, 5½ miles; 40 house services and 250 houses without services. Daily consumption, 180,000 gal. to town and 150,000 to C.P.R.

The first town up stream is Calgary, 85 miles distant; down stream, Medicine Hat, 97 miles distant.

Sewerage system, combined plan; 3½ miles of sewers; 40 house services and 16 catch basin connections; 1 gravity outfall discharging into disposal works 2.5 miles from town.

Town has a Reid incinerator.

Claresholm.—Pop., 1,000; water supply, m.o. Source, Willow Creek; filters into gallery, gravitated to town and is pumped to increased pressure; 4 miles water mains. Daily consumption, 50,000 gal.

The town is supplied with natural gas by a private company.

High River.—Pop., 1,500; water supply, m.o. Source, Highwood River by pumping; infiltrates into concrete well at 600 gal. per min.; 1½ miles water mains; 43 house services; 34 hydrants.

Sewerage system commenced in 1913. Sewage to be discharged by pumping.

The first town down stream is Carmangay, 40 miles distant.

Blairmore.—Pop., 2,200; water supply, m.o. Source, York Creek by gravity; 4½ miles water mains; 200 house services; 8 stop valves and 38 hydrants.

Gleichen.—Pop., 80,000; water supply, m.o. Source, deep well by pumping; 1½ miles water mains; 22 stop valves; 6 hydrants. Daily consumption, 6,200 gal.

Sewerage system, combined plan; 1½ miles sewers, ventilated at man holes; 1 gravity outfall discharging 5,000 gal. per day. Sewage treated in sedimentation basin.

All these cities and towns have municipal engineers and staffs, with the exception of Red Deer and Comrose, where the municipal engineering is looked after by local firms of civil engineers.

THE GREATEST PRACTICAL TEST FOR THE MOTOR TRUCK.

IN *The Canadian Engineer* for October 8, editorial reference was made to the extensive use of the motor vehicle in the European war and to the policies of the belligerent powers toward the subsidization of manufacturers and users. Motorized military equipment extends beyond the main services of transportation of troops and commissariat to a host of auxiliary needs. The various services in which motor vehicles are employed receives a concise but comprehensive study by R. W. Hutchinson, Jr., in The Engineering Magazine for November. The following extracts will be found interesting:

Both light artillery and machine guns are being hauled on motor trucks. In the advance on Liège over a hundred motor trucks were used in carrying machine guns alone. In transporting field guns the cannon are generally placed on a trailer wagon, the carriage on another trailer, while the truck carries entrenching equipment, repair parts, tools, tanks of fuel and oil for itself, etc. Heavy siege guns and mortars are being moved, where road conditions permit, by two large tractor trucks in side-by-side fashion; but the 30-horse team is still being largely used for the heaviest siege guns. Trucks may serve as towing units, but they are too valuable for other services—provisioning the army, for instance. A close comparison of the speed and distances moved by the Germans and French in the war of 1870-1 will disclose the fact that to-day with motor transport the armies are operating at twice the distance from their base compared with the work 44 years ago.

Also without motor trucks, the immense armies now measured in millions instead of thousands would be difficult indeed to provision, as the battle lines have extended from 100 to 250 miles front, and have shifted so rapidly in position that if dependence were just on army mules supplying them with food, movements would be slow, the fighting efficiency of the men greatly impaired, and the slaughtering of the huge herds of cattle now necessary to victual the vast hosts would make sanitation impossible, leading to malignant disease and pestilence. Again, space where such prodigious numbers are now employed is valuable. A motor-transport train occupies only one-third of the space of the animal-drawn wagon, and being positioned much farther behind the army, causes less congestion between the main army and its auxiliaries and be-

tween the army and its base. Moreover, half of the load carried by animal-drawn army transports is a "non-paying" load, as it is food for the motive power—the mules; the efficiency is very low and the speed but a third that of motor transports.

The number of wounded in the present war is reported to be unexpectedly great, due to small-calibred, high-penetrating-power steel bullets; hence the carrying of wounded to hospitals in motor ambulances to save time and lives and to pick up the wounded rapidly is as important as motor supply trains. The usual form of motor ambulance in the service of both the French and German armies is in general appearance similar to the now more or less familiar automobile ambulances of city civilian service. Inasmuch as they are expected to do cross-country work, they are usually modified or standard passenger-car chassis of larger wheel base, arranged with stretchers in decks along the sides, and collapsible, removable seats for the less severely wounded. A number of army motor ambulances are, however, mounted on truck chassis and are veritable modern travelling hospitals, as for example, the Boulant type (named for its originator) field hospital of the French army. The body of this moving hospital (which, though of restricted capacity, adequately meets the surgeons' requirements) consists of three compartments—the forward one containing electrical apparatus, the middle one an operating room, and the rear division radium and X-ray equipment. The wide compartment bodies mounted on long-wheel-base chassis are lighted by roof windows and dome lights, with space enough in the operating room for tables, stands, and other absolute essentials. Electrical sterilizers in the front compartment sterilize 15,000 liters of water in 24 hours by the use of ultra-violet rays. Fitted alongside of the body are folding tents for hospital service, the interior of course, being too small to keep the patient permanently there. These Boulant field motor-hospitals are accompanying the troops in service, or are stationed at temporary convenient points. When mobile they can travel at a speed of 18 miles per hour. The number of these Boulant hospitals is small, however, and even the large number of standard motor ambulances are inadequate, so passenger cars and motor omnibuses of large carrying capacity are being requisitioned. When the veil of censorship is lifted and we get a detailed report of the frightful conflicts, the motor-vehicles' service in saving the lives of thousands of wounded will be a bright and comforting commentary.

In the aviation corps of the armies a two-wheeled trailer on which is mounted a canvas-covered frame constituting a portable hangar for aeroplanes is being pulled by a light truck at a speed of 18-25 miles per hour. These trucks carry, in addition to the renewal parts for themselves, extra parts for the aeroplanes, motor fuel, etc., and when a number are concentrated in one zone or section they are maintained in fit operating condition by a motor aeroplane-repair shop, consisting of a large, wide-bodied motor truck fitted up with an assortment of machine tools, small lathes, drills, a small forge and anvil, with tools power-driven by the truck's own engines through small electric motors. Skilled mechanics qualified to do repairs and adjustments on aeroplanes and motor vehicles accompany these ingenious portable machine shops. The French and German infantry are also equipped with a number of aeroplane destroyers, which are light, swift, armored motor trucks with superposed rapid-firing guns of 7-mile range, shooting a projectile of special type of 4.1 kilogrammes weight with a muzzle velocity of 670 meters and 93.8 meter-tons energy equivalent. Mounted in roofless steel towers and with a 45 degree inclination of muzzle of these aeroplane-destroying guns, the projectile has an ascent of 3,700 meters; with 75 degrees angle, 7,910 meters. The turret walls are such as to give a sweep of the gun a considerable distance above. Sighting of the gun is effected by means of a hand wheel working free of the pointing angle and the angle of the earth, final aiming being made by telescope with rigid eye-glass. Twisting reaction is arrested automatically. Armor plate protects gun and operator from light projectiles, as well as the vital mechanism of chassis and projectile receptacles along the sides of the truck.

Armored motor trucks operating both on railways by means of special flanged wheels and in regular manner, equipped with mitrailleuse, machine, and other forms of light guns or loopholes for sharpshooters, are being used to harass advance forces or cavalry. In addition, many hundreds of motorcycles carrying small quick-firing guns are being used to disperse advance scouts.

Quick and efficient communication between the tremendous forces of combatants with battle fronts of 50 to 250 miles is no longer possible by scouts, couriers, and heliographic devices. The long-range combat with terrible engines of destruction means radio or wireless communication, and every one of the Powers now at war is employing portable wireless telegraph plants carried on motor-truck chassis geared for speeds of 25 to 35 miles per hour. The truck motor drives an electrical dynamo which generates the primary current of the high-tension transformer necessary in radio transmission, and the complete paraphernalia of condensers, interrupters, collapsible antennæ, etc., are carried on the truck which is generally fitted with a protecting shield for the driver, and a special convertible body with sliding panelled sides which can be tightly closed in stormy weather. These motor-truck wireless outfits having an effective land range of 200 to 300 miles have enabled the armies of the "Dual Alliance" and the Triple Entente to keep in communication with their base, wings, and reinforcements—a task impossible in modern warfare without the radio telegraph and—most important—the motor truck on which to move swiftly the instruments and their relatively large space-requiring auxiliaries from position to position.

Numerous motor-searchlight outfits are being used by the armies of both sides. Like the wireless field outfits, the engine of the motor truck on which they are carried generates the electrical current for their operation. The searchlight is mounted on a four-wheel platform truck with rubber-tired wheels, which enable the auxiliary searchlight truck to be quickly and easily demounted and remounted and drawn independently by men or horses if required, and enable the motor truck to be utilized for other purposes. These portable searchlights, being thus self-contained, independent power plants, have permitted the dreadful night battles of which censors have undeleted enough to let our imagination portray in part the horror. These portable searchlights and their allied motorized aerial observation ladders have indirectly served as terrible allies of death and destruction. The aerial observation ladders are carried on long-wheel-base fast motor trucks and in general appearance are like the motorized hook and ladder outfits of modernized city fire departments.

The supplying of ammunition to the armies of 15,000,000 men now, or that probably will be, participating, will be a gigantic task—a task in feeding thousands of machine guns that use cartridges at 400 per minute, second to feeding the prodigious troops. only bigger-capacity motor trucks moving 3 to 4 times faster than horse-drawn ammunition wagons can be equal to the task.

Fig. A.—Main buildings of a typical modern creosoting plant.

THE BATTLE AGAINST ROT

WHY CANADIAN RAILROADS AND MUNICIPALITIES ARE PREFERRING TREATED TO UNTREATED TIMBER — DESCRIPTION OF METHODS USED AND RESULTS OBTAINED — SOME NOTES ON THE WOOD PRESERVING INDUSTRY IN CANADA.

CANADA'S rapid railway growth—thirty thousand miles now, compared with half that amount twenty years ago—and the increasing cost and decreasing supply of good ties, has attracted the attention of the wood preserving industry to the Dominion. Forestry experts claim it takes sixty years to grow a tie, and that we place it in the track to rot out in from five to seven years, whereas it would give from eighteen to twenty-five years' service if preserved, or treated, before being used.

On this continent in 1885 only 120,000 ties were treated out of a total of 50,000,000 used, while in 1912 about 30,000,000 were treated out of about 150,000,000 used. In other words, only about 1/400th part of the ties were preserved in 1885, while in 1912 1/5th of all the ties used were treated. In Canada alone in 1910 practically no treated ties were used. In 1911, 200,000 ties were preserved before being placed in the roadbed. This was 1.4 per cent. of the total number used. Last year about 2,500,000 ties were treated, or 10 per cent. of the total number used. This shows that the Canadian railways have commenced the battle against rot.

Rot is the chief cause of failure of timbers such as ties, paving blocks, piles, etc. It is the breaking down of wood fibre that is caused by the growth of small plants organisms known as fungi. The spores or seeds of the fungi, which are usually carried by the wind, alight on timber and grow, sending microscopic threads or rootlets into the timber. These organisms live on the timber as food, causing the eating away or breaking down of the wood fibre.

Certain amounts of each of four things are absolutely essential to the existence of these fungi; namely, air, moisture, heat and food. Take away entirely any one of these four, and the fungi cannot live. The timber cannot be protected from air except in occasional instances, such as piles that are entirely submerged, in which case the timber needs no other protection from fungi, but may be exposed to teredo attacks.

It is also difficult, as a general rule, to protect the timber from moisture, but where it can be so protected the growth of the fungi is stopped. This is shown, for instance, by the excellent condition in which one often finds very old timber in interior construction.

If one could keep timber at or below the freezing point—say, in a cold storage plant—fungi could not live; but from the practical standpoint it is impossible to protect timber from heat.

Therefore, the only thing that can be affected to destroy the growth of the fungi—the only one of the four essential conditions that can be removed—is food. The fungi have only the wood fibre for food, and if that food can be rendered poisonous, the wood will be preserved against their attacks. This is done by treating the wood with a highly antiseptic fluid.

To properly treat a tie in order to preserve it against decay requires a modern treating plant of considerable cost and complexity. In 1885 there were only three of these plants in operation on the continent, while there are now over one hundred such plants in existence, with an aggregate capacity of over 100,000,000 ties a year. In Canada we have but five of these plants, all built within the last four years, with an aggregate capacity of approximately 4,500,000 ties per annum. These plants are located at Sydney, N.S.; Fort Francis, Ont.; Trenton, Ont.; Transcona, Man., and Vancouver, B.C.

Such plants consist of retorts, pressure pumps, vacuum pumps, proper gauges, storage tanks, measuring tanks, etc. Fig. B is an interior view of the retort house at the Trenton plant. The retort (1) is shown at the right of the photograph. It is 134 feet long, 7 feet in diameter, and has a net capacity of about 2,500 cubic feet of wood.

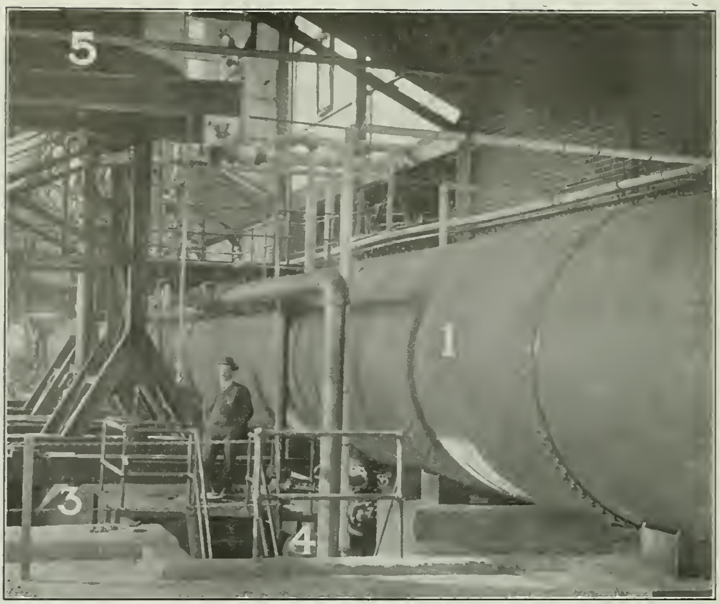


Fig. B.—Interior of retort house. 1, Retort. 2, Retort door. 3, Receiving tank. 4, Pump. 5, Overhead tank.

The retort is built of riveted boiler plate to withstand 225 pounds pressure per square inch. There is a door (2) at each end which is securely bolted and sealed after the retort has been charged. A receiving tank (3) holds the creosote oil that is drained from the retort after the finish of the pressure treatment, and also after the finish of the vacuum treatment. A centrifugal pump (4) forces this oil from the receiving tank to the overhead tank (5), from which the supply is drawn when the treatment is begun.

Steam coils run along the bottom of the retort for its entire length in order to regulate the temperature of the preservative during treatment. The end of these coils can be seen in Fig. E. At the operator's station is a board on which is mounted a number of gauges, both indicating and recording. One gauge indicates the pressure in the retort and one records it on a timed sheet. The amount of vacuum is indicated by another gauge and recorded, with the time, by still another. The temperature is indicated and recorded according to time.

Among the plant's equipment are several trains of tram cars, such as are shown in the centre of Fig. C. These are used to convey the ties and lumber into the retort for treatment. Sixteen tie lengths are used to make up a train; a tie length to each tram car; each tram car holding about 60 ties. The train is pushed by an electric locomotive right into the retort. Fig. E is a view of the end of the retort after a train has been pushed in and just before the door is closed. The stretch of track shown in the foreground of Fig. E is removable, the two rails simply forming a connecting link between the end of the track which runs from the yard and the track in the retort. These links, of course, must be taken up before the door is closed. The cars are not coupled, but are so constructed that they can push against each other without disturbing the load, a cast steel bumper being attached to each end of every car. A wire cable is fastened to the car farthest from the locomotive, so the train is easily drawn out.

A different type of tram is used for treating paving blocks. A train of them is shown at the left of Fig. D. After these trams are filled with blocks, a perforated slide closes across the top of each tram, holding the blocks in place but allowing the creosote oil to flow through the perforations and fill the car.

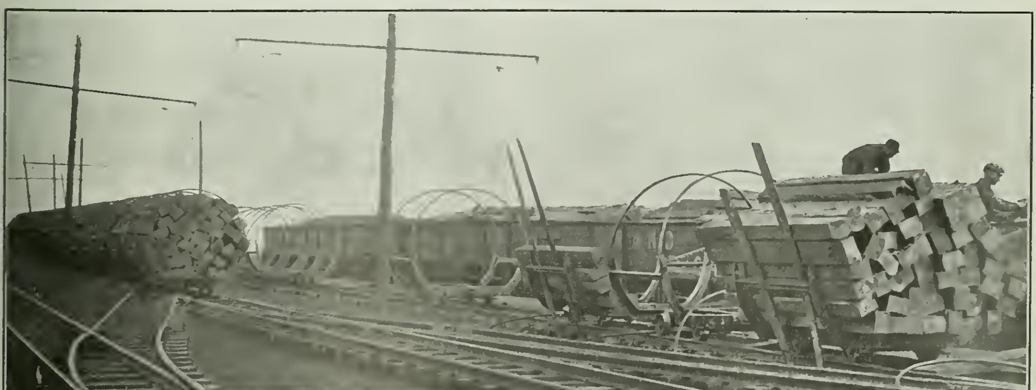


Fig. C.—Train of ties just drawn from retort, and one type of the trams used.

The paving block mill which operates in connection with the treating plant and manufactures the lumber into paving blocks, consists of a conveyer, a planing mill, saw tables with saws, etc. Seasoned lumber is loaded onto the conveyer, shown in the foreground of Fig. A, which carries it into the block mill. It passes on live rolls in a straight line through the planer and onto the saw table, on which it is fed into a mill of from sixteen to twenty saws which cut fifteen to nineteen blocks at a time. The sawn blocks drop onto another conveyer which carries them from the mill. As they pass out they are inspected and, from the conveyer shown in Fig. D, they are loaded into the cages, as the paving block trams are called. Sixteen of these cages are used to make up a train for each charge. Each cage contains about forty square yards of blocks.

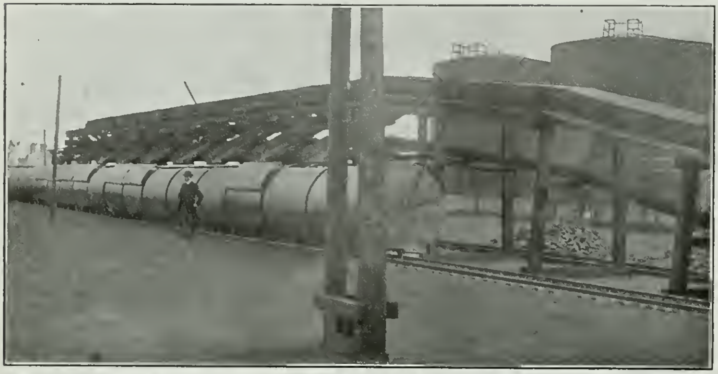


Fig. D.—Conveyer filling trams with paving blocks. Storage tanks in background.

Ties and timbers from the seasoning yard are loaded onto tram cars such as are shown in the centre of Fig. C and a number of trams placed together to make a train such as is shown at the left of Fig. C, ready to be pushed by the electric locomotive into the retort. The trains of block cages are made up at the conveyer at the end of the block mill, as shown in Fig. D, where they have been filled with blocks.

When the treatment is started after a train of paving blocks, ties or lumber has been placed in the retort, and the end doors closed and hermetically sealed, oil is allowed to flow into the retort from the overhead tank, filling the voids around the timber. Then by means of steam pumps additional oil is forced into the retort to obtain the amount of pressure required to thoroughly saturate the wood, 100 to 180 pounds pressure being used, according to the kind of wood. Upon completion of the pressure treatment the pressure is released and the oil is rapidly drawn into the receiving tank. A vacuum of from 23 to 27 inches is then quickly created in the retort by means of a special arrangement of vacuum pump and condenser. This vacuum is sustained from an hour to an hour and a half, and draws from the wood the surplus oil. After this surplus oil is drawn off, the doors of the retort can be opened and the train withdrawn.

During the treatment heat plays an important part as well as pressure and vacuum. The temperature during the pressure treatment is never allowed to drop below 150 degrees F., nor to rise above 190 degrees F. The degree of penetration depends largely upon the temperature of the oil; the higher the temperature, within certain limits, the freer the liquid will flow and the more easily it will enter the pores of the timber after the timber has become warm and the pores expanded by the heat. Some kinds of wood offer little resistance to the oil, while other kinds offer great resistance, depending on the size of the pores, the smoothness of the cell walls and the extent to which material obstructions are contained in the cells. The temperature, pressure, vacuum, etc., are readily regulated by the operator, all valves and the controlling apparatus being near the station from which he watches the process.

A complete record is kept so that any official of the creosoting company, or the customer's representatives, can check the operator's discretion and skill. These records are kept, and should it be desired to refer to them at any time for any reason, even after a lapse of many years, one can easily do so.

A clocklike device shows the amount of oil in the overhead tank, both before and after treatment. The difference, of course, is the net amount left in the charge. This method is remarkably accurate. It is checked up monthly by actual and precise measurements, and is also verified by weighing the timber before and after treatment. The whole process of treatment takes from three to five hours for ties and from four to eight hours for paving blocks. If the ties are well barked, in good condition and well seasoned, the treatment does not take so long as it does otherwise.

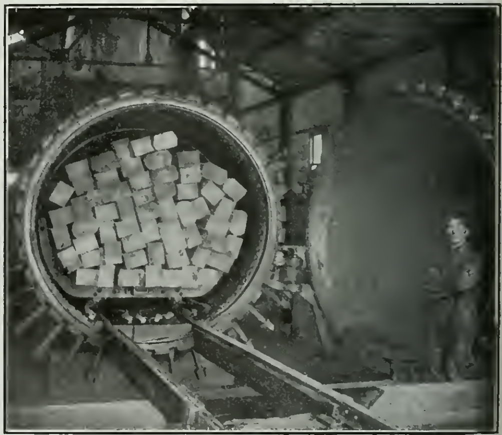


Fig. E.—End of retort after insertion of charge but before door is closed.

Various preservative fluids are employed, but that which is in most general use is creosote oil. Of the five plants in Canada equipped for preserving wood on a large scale, all except one use creosote oil. The plant at Fort Francis, Ont., uses chloride of zinc. Unless the timber is penetrated so deeply with the preservative that checks

or openings cannot reach beyond the treated zone, the spores will find their way in through the checks to the untreated portion and cause interior rot, which is frequently misnamed "dry rot." The depth of penetration of the creosote oil depends on the amount of oil that is forced into the wood, yet it is not necessary for the preservation of the timber to leave so much oil in the timber as must be put into it in order to obtain the required penetration. Therefore, many plants use the process whereby a large quantity of oil is forced into the timber, thus insuring thorough penetration, but whereby a considerable portion of this oil is afterwards drawn from the timber by the creation of a high vacuum. This leaves in the timber only the amount of oil that is needed, and the oil is evenly distributed throughout the timber (except impenetrable heart wood), instead of simply being distributed densely at the surface. By this method proper penetration can be secured without adding so greatly to the cost as would be done if all the oil were left in the timber that had been put in to obtain the penetration.

Following is the record of a treatment recently given an order of Norway pine paving blocks, three inches wide by four inches deep, for the City of Toronto:

Creosote oil in each cubic foot of timber at end of pressure.	Net gallons remaining in each cubic foot at end of vacuum.
34.35	22.41
25.20	19.61
26.60	19.57
26.50	20.61
27.03	21.53
25.74	20.64
24.80	19.01

The objective was a twenty-pound treatment. It will be seen that the net average was 20.48 pounds. These blocks were treated at the plant of the Canada Creosoting Company, Limited, at Trenton, Ont.

After the blocks, ties or timbers have been treated, the penetration is inspected by the representatives of any inspection company who may be present on behalf of the purchasers of the materials, by cutting the blocks in two by means of a hatchet, or extracting small borings from the ties and timbers. These borings are made with a Swedish instrument which resembles a miniature core drill in its action. A perfect core several inches long and about 3/16ths of an inch in diameter is taken out of each timber that is bored. Examination of these cores shows the depth and uniformity of penetration.

The method of loading ties onto the railroad cars after treatment is shown at the right of Fig. C. The handling of large timbers, both before and after treatment, is all done mechanically.

Before ties and timbers are treated, or before lumber is cut into paving blocks, it is stacked on the seasoning yard for months, to become properly seasoned. The lumber is stacked in open piles, so as to permit the free circulation of air, for three to five months. The ties are piled in such a manner as will permit of good air circulation and at the same time not allow sufficient exposure to cause checking. It requires from 6 to 10 months to properly season ties. Fig. F shows the manner of piling ties.

Fig. A is a general view of the Trenton plant. The buildings, reading from the left to right, are the block mill, machine shop, boiler house, office and retort house. The company also owns its own tie camp, north of Trenton, which it organized in order to get hard wood ties.

The trestlelike structure in Fig. D is the conveyer running out from the block mill. The sawn blocks are carried out on this conveyer. Chutes will be noticed running from the conveyer to the cars; and when the cars are pulled into place under these chutes, trap doors are opened in the conveyer just over the chutes and the cars are filled. In the background of Fig. D can be seen large tanks for storing oil, holding 150,000 gallons each.

Creosote oil, the preservative used at the Trenton plant, is defined scientifically as any and all distillate oils boiling between 200° and 400° C. which are obtained by straight distillation from tars consisting principally of compounds belonging to the aromatic series and containing well-defined amounts of phenoloids. Or, to be less

Fig. F.—Tie stacking yard.

technical, creosote oil might be defined as a distillate from the tar which is produced as a by-product in the manufacture of coal gas from bituminous coal by the retort method; or a distillate from the tar which is produced as a by-product in the manufacture of coke from bituminous coal in by-product ovens; or a distillate obtained from a mixture of these two kinds of tar.

Creosote oil is highly antiseptic and thoroughly protects the timber against fungus growths. For ties, eight to twelve pounds per cubic foot (about 2½ gallons per tie) is left in the timber, while for paving blocks from sixteen to twenty pounds per cubic foot is left in. Creosote oil may have a preservative value from physical properties as well as from its antiseptic or poisonous nature. This is especially true when applied to paving blocks. It may be capable of adhering to the cell walls and fibre of the wood with such permanency as to prevent conditions favorable for the development of elements destructive to timber. With the idea of obtaining the greatest prevention, both chemically and physically, pure coal-tar of low carbon content is frequently mixed with the creosote oil.

During the past few months there threatened to be a serious shortage of creosote oil on this continent owing to the war in Europe, but the release by the British government of a number of cargoes of creosote oil has helped the situation for the time being at least. England and Germany are the leading producers of creosote oil distilled from coke-oven coal-tar. When coke is manufactured in bee-hive ovens the coal-tar is burned in the process. On this continent most coke ovens are of the beehive type, while in Europe they are of the by-product type. Therefore we are largely dependent on Europe for our supply of coal-tar and creosote. The only by-product ovens in Canada are at Sydney, N.S., and Sault Ste. Marie, Ont. A bee-hive oven costs only about one-third

or one-fourth as much as a by-product oven, which explains the popularity of the bee-hive ovens. The quality of coal for coking in Europe is not so good as on this continent, and requires the by-product oven in order to make the greatest quantity and best grade of coke. Therefore the use of the more expensive by-product oven is not altogether a matter of choice in Europe.

Creosote oil is one of the fractions of crude coal-tar obtained by its distillation. It is the fraction coming off between the benzol and carbolic acid compounds, which come off at low temperatures, and the pitch, which remains in the still at the highest temperatures. Coal-gas tar usually has a high percentage of free carbon which should be filtered out, or otherwise removed, before such tar is ever mixed with creosote oil. Refined coal-tar is often added to the creosote oil in preparing it for use in wood preservation, as the treatment is more permanent when the mixture is used than when only creosote oils of low specific gravity are used, as there is a marked evaporation of the low-boiling fraction of the creosote oil. The coal-tar and the creosote oil, when mixed, combine thoroughly, and cannot be separated again, either physically or chemically.

Up to the present only wood block and ties have been treated at Trenton, but it is expected to treat timber for station and outdoor platforms; switch ties; dimension timbers; decking; flooring for docks, bridges, fire halls, warehouses and heavy manufacturing plants; crossing planks; fence posts; signal poles; snow fences; piling; mine props; telegraph and telephone poles; cross arms; mine timbers; tie plugs; wooden pipe; and all material for breakwater and marine work.

The first ties ever treated in eastern Canada from Canadian timber were creosoted at the Trenton plant last month for the Toronto, Hamilton and Buffalo Railway. The only woods used so far have been beech, birch and maple for ties, and southern yellow pine and Norway pine for wood block, but spruce, tamarack, fir, hemlock and other woods will probably be treated later on.

Special attention will be given to the treatment of mine props, as timbers for use in mines decay very readily, owing to ideal conditions of moisture and temperature for fungus growth. Much of the failure of mine props now attributed to breaking and splitting is due primarily to rot. This can be prevented, and the original strength of the timber maintained, by creosoting or otherwise preserving it. The creosoting of mine timbers is not so expensive as come other forms of creosoting, because it is not necessary to obtain such great penetration. The uniformity of temperature and moisture in mines, and the lack of exposure to the direct rays of the sun, result in no checking taking place, so that it is not necessary to get such deep penetration. A much lighter treatment than is given other timbers will therefore prove satisfactory. But this does not necessarily mean that any merely superficial treatment is sufficient.

The difference in strength between untreated and treated ties and timbers, except in the case of those treated with heavy oils which protect the timber from excessive moisture and add to its strength, is so slight as to be of no importance. This assumes that ties and timbers are properly treated and not injured by steaming or excessive heat during treatment. The drier that wood is kept, in ties and timbers, the stronger and better service they render.

The very great value derived from the treatment of wood is not only the prevention of the rot which makes the wood useless. The treatment maintains the original strength of the timber, especially in the case of ties treated with oil, and causes it to resist mechanical abrasion and wear longer. Furthermore, when ties are properly seasoned before treatment and preserved with creosote oil, the oil resists moisture and prevents the ties from becoming soft and spongy.

The added life due to creosoting depends upon the quality of treatment, and upon the kind of timber and the manner in which it is used. It is only fair to say, however, that creosoted ties will last from three to five times as long as untreated ties, while the cost of treatment does not double the cost of the tie. Therefore the great saving in the use of treated instead of untreated ties is apparent. This saving is even more pronounced in the case of other timbers.

NEW SAFETY AND DETONATING FUSE.

In a paper presented at the Pittsburg meeting in October of the American Institute of Mining Engineers, Mr. Harrison Souder, of Cornwall, Pa., directs attention to a safety detonating fuse by the use of which he claims misfires in blasting may be eliminated and safety in blasting operations provided. The detonator, which is known as the Cordeau detonant, is sold under the name of Cordeau-Bickford, and consists of a lead tube 5 to 6 mm. in diameter, filled with trinitrotoluene. It is applicable to all classes of mining, but is of especial value in connection with deep-hole blasting in open-cut mine or quarries, or any operations where a large number of holes are to be shot at one time. After detailing the superior results obtained with the use of this fuse in actual practice, the author summarizes its peculiar advantages as follows:

(1) There is no danger in handling or storage of the fuse. It cannot be exploded by friction, fire, or ordinary shock. It requires the use of a strong blasting cap properly attached to explode it. In blasting charged holes, the cap or exploder can be applied outside the hole, thus avoiding the danger of burned powder caused by side spit from ordinary fuse; also any risk of accident while tamping and the risk from a portion of an unexploded charge accompanied by a cap remaining in the debris from a blast is entirely obviated.

(2) The average rate of speed of this fuse is estimated to be close to 17,000 feet per second, so that when it is used, the explosion charge is detonated instantly throughout its entire length, instead of at one point as is the case with the blasting cap or electric exploder.

(3) It is known that the speed of an explosive decreases as the explosion wave travels away from the detonator. That the powder in a hole has the strongest explosive effect around the exploder is evident from an examination of the face of the bank after a shot. This can be demonstrated also by placing sticks of dynamite on the ground end for end, about 6 inches apart, with the cap in the first stick. The explosive force gradually lessens until it finally ceases to progress, leaving the farthest stick unexploded.

By using this fuse, the charge is detonated instantaneously throughout its entire length. This results in a saving of about 10 per cent. of explosives as determined by results obtained at Cornwall and elsewhere. It is not affected by heat, cold, or moisture, and lasts indefinitely without deterioration.

It is wound in continuous lengths on spools containing 100, 200, or 300 feet each, and weighs about 7 pounds per 100 feet. It is accepted by transportation companies without restrictions except that it shall not be packed with other high explosives.

THE COST OF POWER AS A FACTOR IN LOCATING INDUSTRIES.

By H. E. M. Kensit, M.Can.Soc.C.E.

THE above title implies a subject that is of interest to every progressive city in Canada. There is a very general impression that the cost of power is a largely determining factor in inducing most industries to select a location, and constant repetition of this claim has caused its general acceptance. Little investigation appears to be made, however, as to the basis of this belief, in which industries the cost of power is an important item and as to what proportion the cost of power bears to the total cost of production or total expenses.

This impression leads cities, which means the councillors in power in any particular year, to embark on expensive and in many cases doubtful projects for providing cheap power, without having any definite knowledge as to what industries the general local conditions will make it possible to locate, or of the relative importance of cheap power to such industries.

The questions of distribution facilities, proximity of raw materials, extent of labor market, etc., are awkward matters that cannot be controlled by that year's council, and they are, therefore, left in the background, while it is decided to enter on some extensive project to provide cheap power in the hope that this will make everything all right and produce a rush of industries anxious to take advantage of it.

The fallacy of this view has been impressed upon the writer by various personal experiences and has led him to collect a large amount of data on the cost of power in different industries. A large amount of manufacturing data has also recently become available in the statistics issued by the United States and Canadian census bureaus, the Ontario Bureau of Labor and other sources, and it is, therefore, possible to tabulate the average proportionate costs of many different industries in a manner to give an approximate idea of their relative importance.

A comparison of these statistics by such factors as the per cent. of wages to gross value of product and the ratio of the value of the product to the capital employed shows that, while the figures vary appreciably in the two countries in some individual industries, if the average is taken over a considerable number of miscellaneous industries they are in very close agreement and that, therefore, the conditions are not widely different. On the whole, the United States statistics are the most satisfactory to work to, because the explanation given of the meanings of the terms, the precautions taken and exactly what the headings include, is much more complete and specific than in the others. It involves some little labor to dig out the figures and give them in the form shown, but the tables that follow are deduced direct from the census figures, the only assumptions being the rate for interest and depreciation on the stated capital and an assumed price per h.p.-year for the stated horse-power employed.

A certain number and class of industries will attach themselves to every town in proportion to its population and other local conditions, entirely irrespective of the cost of power.

Such industries in a town of 5,000 population would be, say, a brick-yard, steam laundry, machine shop, flour and grist mill, planing mill, mineral water factory, elevators, etc. When it reaches 12,000 or 15,000 there may be added, still without regard to cost of power, further factories of the same class and in addition a foundry, brewery, sash and door factory, tent and mattress factory, etc. At 50,000 population, and still without regard to cost of power, there would probably be, in addition to the foregoing, some or all of the following: box-works; abattoir and cold storage, harness factory, soap works, creamery, show-case factory, etc.

The results are so general that a little investigation will satisfy anyone that they are obtained under normal conditions irrespective of the cost of power.

The reason can be clearly seen from Table I. on consideration of the percentage cost of power, compared to other items of expense incurred by miscellaneous medium sized industries. It will be seen that at the assumed figure of $50 per h.p. year the highest figure for the cost of power in per cent. of total costs is under 6% and the average is 3%.

The intention in this and the following tables is to give a fairly approximate idea of the proportion that the cost of power bears to the other items of expense, not to attempt to give an exact figure of the cost of the power itself, which must vary in each case in each industry.

Before proceeding further it will be well to explain the basis on which this table is constructed, so that those interested can make any allowances they see fit.

The total capital employed is given in the census reports for each group of industries and it is specified that the expenses given do not include interest and depreciation.

"Materials" include all raw materials, mill supplies and containers. It also includes (as given in the census reports) fuel, rent of power and heat; and fuel includes all fuel used whether for heat, light or power or for process of manufacture.

Salaries and wages include labor for power and this latter cannot be given separately.

Power. The census returns show the primary power employed in each industry, but do not give the cost of power separately, this being included in "materials" and in wages, as above stated. The cost assumed for power has, therefore, been deducted from the amount given in the census reports for materials and the amount so deducted represents only fuel, oil, stores and water and rented power, or the equivalents. The writer finds that the average proportion of costs of producing power in factories, from a large number of individual cases where the costs were accurately kept, is as follows:

Fuel	50.00%
Oil, stores and water	4.25%
Wages	17.00%
Repairs	4.25%
Interest and depreciation on power plant at 10% on investment	25.00%
	100.00%

To correctly show the percentage cost of power it would therefore be necessary to correct the interest and depreciation column and the salaries and wages column shown in the tables. This can be easily done for any particular case but to do it to the whole of the table on an assumed cost of power would diminish the value of the original figures. Furthermore, it is not necessary to do so to support the contention as to the low percentage cost of power in miscellaneous industries.

If, for instance, taking the averages of the columns, power at $50 represents 3% of the total costs and we assume that power costs 25% more or less than $50, this will only be 25% of 3% or 0.75% on the total cost taken

as 100%, but 25% on wages or materials would be 5.7% and 13.5% respectively on the total costs.

The method by which Table I. is figured is shown by the following sample calculation:

Census Figures for Totals per Establishment.

Primary horse-power	69.5
Capital invested	$68,500
Expenses—	
Salaries and wages	16,250
Materials (including power)	45,200
Miscellaneous	7,240

From which the following is deduced:

Interest and depreciation, say 12%	$ 8,220	10.7%
Salaries and wages	16,250	21.2%
Power: 69.5 h.p. @ $50 per h.p.-year	3,475	4.6%
Raw material and general supplies	41,378	54.0%
Miscellaneous	7,240	9.5%
	$76,563	100.0%

The relative position of industries as power users can be obtained in a different manner and is shown in Table II. Columns 1, 2 and 3 are calculated direct from the census figures. The last or fourth column is an arbitrary attempt to establish a numerical rating, and while objections may be made to the method, it does establish clearly which industries may be classed as using a relatively large amount of power on the three principal bases. For instance, it is obvious that the cost of power must be a more serious consideration to numbers 27 and 28 than to numbers 3 and 4.

Some of these industries using relatively large amounts of power are shown in Table III. in a similar manner to those in Table I. It would not do to assume a figure of $50 per h.p. year for all these because in some cases this would be prohibitively expensive power.

Steam power for blast furnaces costs about $70, with gas engines using blast furnace gas from $30 to $40. In cement mills the power required is relatively very large but their large plants and good load factor give them low costs and several concerns buy hydro-electric power at cheap rates. Pulp mills are usually in districts where water power is available at $18 to $30 per h.p.-year. The figures for cost of power have therefore been chosen accordingly to give an approximate idea of the relative cost of power in each case.

Looking at these large power-using industries from the location point of view, it will readily be seen that while the cost of power is a serious consideration, matters of raw material, labor market and distribution facilities are still more serious and that it would require a good deal in addition to cheap power to determine their location.

Table I.—Percentage Cost of Power in Miscellaneous Industries. Power Assumed at $50 per h.p.-year.

	Interest and depreciation at 12% on capital.	Salaries and wages.	Power at $50 per h.p.-year.	Raw materials, etc.	Miscellaneous.
	%	%	%	%	%
Boots and shoes	9.8	43.3	1.8	41.4	3.7
Breweries	21.7	16.7	4.5	20.7	36.4
Canning and preserving	9.2	17.3	2.6	62.7	8.2
Carriages, wagons	13.0	28.2	2.5	49.1	7.2
Clothing	5.4	24.8	0.4	56.5	12.9
Creameries	3.2	5.5	1.9	86.2	3.2
Farm implements	20.7	26.0	3.4	37.2	12.7
Flour & grist mills	4.8	3.9	4.9	83.4	3.0
Foundry and machine shops	14.4	33.0	3.4	39.4	9.8
Furniture	9.5	43.8	3.9	34.6	8.2
Lumber, saw and planing mills	5.9	34.5	5.9	42.3	11.4
Meat packing	3.4	5.3	0.3	87.8	3.2
Paints and varnish	10.0	15.1	2.2	61.6	11.0
Woollen goods	11.8	18.8	4.1	60.2	5.1
	10.2	22.6	3.0	54.5	9.7

Table II.—Relative Position of Industries as Power Users.

Industry.	Horse Power. 1. Per Capita.	2. Per $1000 Capital.	3. Per $1000 Value of Product.	Relative Use of Power. Average of 1, 2 & 3.
1. Clothing	0.14	0.16	0.07	0.12
2. Boots and shoes	0.45	0.43	0.19	0.36
3. Canning and preserving	1.13	0.68	0.52	0.78
4. Meat packing	1.92	0.55	0.02	0.82
5. Foundries and machine shops	1.40	0.57	0.71	0.89
6. Farm implements	1.66	0.39	0.68	0.91
7. Car-shops, railroad	0.98	1.23	0.72	0.98
8. Carriages & wagons	1.52	0.72	0.79	1.01
9. Paints & varnishes	2.55	0.56	0.45	1.13
10. Furniture	1.54	0.98	0.93	1.15
11. Electrical machinery and apparatus	1.51	0.60	1.41	1.17
12. Woollen mills	2.07	0.84	0.83	1.25
13. Smelting, lead	3.45	0.20	0.16	1.33
14. Creameries	3.22	1.42	0.37	1.67
15. Petroleum refining	5.45	0.50	0.38	2.11
16. Breweries	5.20	0.56	0.93	2.23
17. Cotton mills	3.35	1.58	2.06	2.33
18. Grindstones	3.72	1.16	3.38	2.75
19. Lumber, sawing and planing mills	3.62	2.51	2.46	2.86
20. Bricks and tiles	3.99	1.95	3.68	3.21
21. Chemicals	7.50	1.34	1.77	3.54
22. Smelting, copper	9.40	1.42	0.42	3.75
23. Iron and steel rolling mills	8.1	2.09	2.13	4.11
24. Sugar and molasses	10.70	1.05	0.58	4.11
25. Oil and cotton seed	9.00	2.11	1.30	4.14
26. Flour & grist mills	12.90	2.44	0.97	5.68
27. Portland cement	12.6	1.98	5.9	6.83
28. Paper & wood pulp	16.0	3.19	4.86	8.02
29. Blast furnaces	27.2	2.41	3.00	10.87
30. Carbide of calcium	37.4	12.1	14.5	21.3

In this connection it is of interest to consider the proportion of power owned by and the proportion purchased by industries. The census summaries of the total power used in all industries show that the percentage owned by the establishments using it is 97% in Canada and 90% in the United States, so that the proportion of purchased power is still quite small in relation to the whole and there must still be a very wide field for central station power.

It is also of interest to observe the large proportion of power, other than water power, used in both Canada and the United States, by industries that are essentially large users of power. This is shown in Table IV., which

gives the total primary power owned by the establishments and excludes electric motors driven by that primary power.

The above particulars appear to indicate clearly that in ordinary miscellaneous industries the cost of power is a comparatively small consideration, that even in industries where the cost of power is a large proportion of the total costs, other considerations of raw material, distribution facilities and labor market are of even greater importance.

Table III.—Percentage Costs in Industries Using Large Amounts of Power.

	Interest and Depreciation at 12% on Capital.	Salaries and Wages	Power. Per H.P. Year.	Power. Per Cent.	Raw Materials, etc.	Miscellaneous.
	%	%	$	%	%	%
Blast furnaces.	13.9	7.4	35	9.8	66.3	2.6
Chemicals	16.5	18.0	50	9.3	47.6	8.6
Cotton mills ...	13.8	20.5	50	9.0	51.7	5.0
Portland cement	30.2	25.4	35	17.4	21.9	5.1
Rolling mills ..	11.9	18.7	50	10.3	54.7	4.4
Wood pulp and paper	17.1	17.6	25	11.4	46.4	7.5

Table IV.—Class of Power Used in Large Industries.

Industry.	Canada, Census 1911. Water Power.	Canada, Census 1911. Other Power.	U. S. Census 1909. Water Power.	U. S. Census 1909. Other Power.
	%	%	%	%
Wood pulp and paper..	94.0	6.0	60.0	40.0
Portland cement	2.3	97.7	....	....
Carbide of calcium	3.2	96.8	....	....
Smelting	2.0	98.0	6.9	93.1
Iron and steel products	0.8	99.2	0.05	100
Cotton	48.5	51.5	24.4	75.6
Flour and grist mills...	52.0	48.0	31.0	69.0
Lumber products	19.3	80.7	5.0	95.0

There is no question that very cheap power has located industries at certain points *where the other conditions were also favorable*, but it is extremely doubtful whether the large sums spent by municipalities in competitive efforts to attract industries by the offer of cheap power produce any tangible results, except where the other essentials predominate and really form the deciding factors in locating the industry.

BRITISH LOCOMOTIVE EXPORTS.

Notwithstanding the war, the British locomotive shipments exhibit, upon the whole, satisfactory results for the nine months ended September 30th, the value of the engines exported to that date having been £2,929,502, as compared with £2,067,316 in the corresponding period of 1913, and £1,430,977 in the corresponding period of 1912. Argentina took British locomotives in the first nine months of this year to the value of £603,766, as compared with £499,254 and £313,432. This result must be regarded as favorable in view of the current disorganization of the Argentina railway interest. It is, however, in British India that the greatest progress in the demand is observable, the value of the Colonial imports having been as follows to September 30th, this year, as compared with the corresponding periods of 1913 and 1912:—

Colonial Group.	1914.	1913.	1912.
British South Africa	£ 64,099	£ 96,831	£148,442
British India	1,322,082	711,910	298,996
Australia	430,950	338,861	237,919

It will be seen that purchases of locomotives upon Australian account have been good this year. The war may exert an unfavorable influence upon Australian development, but thus far it has not had much effect.—Engineering, London.

THE ROYAL ENGINEERS OF THE BRITISH ARMY.

By Geo. Laidler.

FROM the earliest times, engineers have been employed in the field of war on the construction of fortifications, earthworks and batteries for besieging defences. In modern times, however, the application of scientific devices to warfare has given rise to many minor branches of military engineering in addition to the primary duties of fortification and siegecraft, such as the field telegraph service, the flying corps, the construction of temporary roads and bridges for the transport of an army; also works which more properly belong to the realm of civil engineering, such as surveying, the construction of permanent military buildings, railways, piers, etc. All these branches require special knowledge, and consequently the "field companies" and "fortress companies" represent the application of their arm to works of offence and defence in field and siege warfare.

It is difficult to distinguish between military and civil engineers in early modern history, for all engineers acted as builders of defensible strongholds, as well as makers and manipulators of engines of war for attacking and defending them. The annals of the science of glorification record artists, architects and soldiers as being responsible for the design and construction of the various systems. Artillery naturally became just one branch of military engineering; in fact, the word "engine" which, at the time of Chaucer meant "natural talent," or "invention," (corresponding to the latin "engenium" from which it is derived) was formerly used especially to denote a weapon of war, such as the catapult or battering-ram.

By the middle of the thirteenth century there was in England an organized military body of skilled workmen controlled by a "chief engineer." At the siege of Calais in 1347 this corps consisted of masons, carpenters, smiths, tentmakers, miners, armourers, gunners and artillerymen. When Harfleur was besieged in 1415 the chief engineer was designated "master of the King's works, guns and ordnance," and his men numbered 500, including 21 foot archers. About 1450 the engineer branch had developed into the Office of Ordnance, whose duty was to administer all matters connected with fortifications, artillery and ordnance stores.

Henry VIII. employed many engineers to construct coast defences around England, and also added to the organization a body of pioneers under trenchmasters, to clear and repair roads and to remove obstacles to the march of troops. Up to 1715 the commander of an ordnance train was nearly always an engineer, but after that date it was decided to separate the artillery from the engineers. It afterwards became common for the officers of engineers to hold commissions in foot regiments in addition to their rank in the corps of engineers.

In 1757 all engineer officers were gazetted to army as well as engineer rank—chief engineer as colonel of foot and so down the scale to practitioners as ensigns (second lieutenants). In 1782 the engineer grades except that of chief engineer were abolished. Ten years later a small corps was formed, and in 1787 the designation "Royal" was conferred upon it.

In 1802 the title of Chief Engineer was changed to Inspector-General of Fortifications, and from this time up to the conclusion of the Crimean War many augmentations took place on account of the widely increasing duties which devolved upon the officers.

In 1772 the formation at Gibraltar of the "Company of Soldier Artificers," officered by Royal Engineers, was authorized, and in 1787 the "Corps of Royal Military Artificers" was established at home. In 1813 its title was changed to the "Royal Sappers and Miners," doubtless on account of the intrenching and subterranean nature of much of its work. In 1856, after the Crimean War, it was incorporated with the "Corps of Royal Engineers," by whom it had always been officered. There is a School of Military Engineering at Chatham, England, (the headquarters of the corps) where officers are trained, and where the official textbooks on military engineering are compiled.

The ordinary strength of the regular Royal Engineers of the British Army is about 10,000 officers and men, with mounted and dismounted sections. The territorial and overseas forces also include a proportional complement of Engineers. The privates (called "sappers") in the regular Royal Engineers are generally skilled artisans. They are trained in tactics and the use of the rifle and are paid at a higher rate than infantrymen. The utility of this important branch of the service has frequently been shown in the course of the present war, especially on demolitions, entanglements and bridges.

DRAINAGE STRUCTURES.*

By W. E. Atkinson,
State Highway Engineer of Louisiana.

In determining the length of bridges and spans between bents and piers and the size of culverts, consideration is given to the maximum rainfall, amount of run-off, average slope of ground of drainage area, seepage, etc., as included in the same factors governing similar structures under railroad construction. After determining the required opening for waterway, the factor governing the required strength or carrying power of the structure is determined, so far as it is possible, upon the maximum load the structure is likely to be subjected during its bonded life. As to the bonded life of structures of this character, it is figured that they should last until bonds or taxes voted for the construction of same are retired, all structures being computed, however, to safely carry a minimum live load of not less than ten tons, plus 50 per cent. impact and a factor of safety of four.

Standard Plans.—It has been the policy of the highway commission of Louisiana to construct, wherever funds and conditions will permit, permanent structures and adopt uniform and standard plans for bridges and culverts for any particular highway project. However, oftentimes different designs are necessary to meet existing conditions. The type and design of bridges, whether they be of wood, concrete, or masonry, etc., are determined largely by the amount of funds available, and the character and nature of soil for foundation.

Due to the alluvial character of the soil, with the exception of some sections in the northern part of the State, there are instances where it is not safe nor economical to construct the arch type of concrete bridges; even with some of our girder and slab bridges, it oftentimes becomes necessary to provide pile foundations for the piers, abutments and wing walls. In some places it is necessary for these piles to be of concrete instead of wood on account of many reclamation projects, now under way, lowering the ground water which would become detrimental to the latter type of construction.

* From a paper read at the Fourth American Road Congress, Atlanta, Ga., Nov. 9 to 14, 1914.

Uniform Design.—We have found it advantageous and economical to provide, where conditions will permit, a uniform design for all drainage structures, especially for those of concrete construction, that the contractor may use the same drainage forms over and over, permitting thereby much lower bids per cubic yard on such work than otherwise under a system of non-uniform standard designs for such structures, and in addition, many times permitting, without greater cost, greater waterway opening than theoretically computed, resulting in a larger factor of safety, and often providing for some unprecedented rainfall or cloudburst not anticipated. In addition to concrete bridges, the department is building many wooden bridges, both of creosoted and uncreosoted materials; this character of construction predominating in some parishes due to lack of funds for more permanent construction.

Types of Culverts.—The department has installed several types of culverts, that of vitrified clay, cement, concrete, cast iron, wood, corrugated galvanized iron, etc., the type of construction being governed by the available funds and topographical features together with character of soil encountered in foundation. However, where practicable, concrete has always been recommended.

At many places, however, we have found it impracticable and not economical to use concrete culverts and others of a monolithic character, especially in some of the bayous and coulees. In one place in particular, it is recalled, where the foundation in one bayou was so poor that a strip 2 in. x 2 in. x 16 ft. was pushed down its full length in the bottom of the bayou, and could have been pushed farther if the strip had been longer. This bayou was 250 ft. wide across the top and 25 ft. deep, and the only opening necessary was that of an equalizer with an area of some 28 sq. ft. to be filled over with earth, thereby making a bridge of earth and of an equalizer. The equalizer installed at this particular location was a 10-gauge 6-ft. diam. corrugated galvanized iron pipe culvert. The entire cost of this combination bridge, if it may be so termed, amounted to $2,059.27, including an item of $215.73 for riprap, whereas to have bridged the bayou with concrete, or to have attempted to build a concrete culvert, would have made the cost very much in excess of this amount.

Due to debris, drift wood, and other extraneous matter, our highway department has adopted a policy not to install any culverts of less than 18 in. in diam. where possible, it preferring that they should be not less than 24 in. in diam. Experience has shown that culverts of these sizes have proven more satisfactory and given better service, requiring less maintenance both for road and culvert at such places than when culverts of smaller diameter are used, even though the smaller culverts are ample to carry the water, due to the ineffectiveness of the latter from drift choking and filling them up.

PACIFIC GREAT EASTERN RAILWAY CONSTRUCTION.

The British Columbia Government has decided to guarantee bonds to enable the Pacific Great Eastern Railway Company to float a loan of $5,000,000, to provide for further construction.

The American Society for Testing Material has added to its specifications for reinforcing steel rolled from billets, an intermediate grade between the structural and hard grades. The new grade has a yield-point of 40,000 lbs., and an ultimate tensile strength of from 70,000 to 85,000 lbs.

Editorial

THE ROYAL CANADIAN INSTITUTE AND SCIENTIFIC RESEARCH.

Mr. Frank Arnoldi, K.C., President of the Royal Canadian Institute, has announced that the Institute, with a mature and comprehensive knowledge of the fact that the necessities and welfare of every member of the community and the attainment of efficiency are bound up with the advancement of the scheme of co-operation of science with industry, is about to undertake to promote the establishment within itself of a Bureau of Scientific and Industrial Research. As Professor Haultain observes, in his open letter commending the procedure, it marks the return of the Institute to the channel molded for it in the minds of its founders over half a century ago.

Science and Industry must co-operate if Canada is to make any material advance in the readjustment of industrial greatness, of which this war is the curtain-raiser. The universities have long realized this, and have not hesitated to extend offers to co-operate with the Institute in its move. But, in Canada, as previously in England, there has been some disinclination on the part of the industrial and business man to embrace the advantages which Science has proffered. On the other hand, it has not been the enemy's militarism but the co-operation of Science with German industry that has placed that country where it is industrially. Enemy though it is, the German nation has given the world a great lesson.

Down in the University of Pittsburg, there is nearing completion a home for the Mellen Institute of Industrial Research and School of Specific Industries. It will provide ample accommodation for seventy researchers besides accommodation for graduate courses. Industrial fellowships constitute the basis of the system, and these are constantly increasing in amounts subscribed for their maintenance by industrialists. We have not the space here to describe the system as fully as we would like; for although in its infancy the Institute has gained world-wide fame through its investigation of the Smoke Problem. Suffice it to state at this juncture that there is every indication of a successful start on the road to the ideal for which it is striving. This ideal may be read from the inscription on the door:

> "This building is dedicated to the service of American Industry and to young men who destine their life-work to the Industries; the goal being Ideal Industry, which will give to all broader opportunities for purposeful lives."

In a quiet way the graduates of the Faculty of Applied Science and Engineering of the University of Toronto raised a fund among themselves and have financed a considerable amount of engineering research. The movement has had the closest co-operation of the the University of Toronto, and the results obtained in a recently completed fellowship will, when published, be found very valuable.

The Royal Canadian Institute, in its revival of scientific investigation in relation to Industry, will receive warm support from the scientific world, and there is little doubt that the organization will make a creditable showing in making Canadian industry more efficient in its manufacturing practices.

LAYING CONCRETE ON THE LEVEL.

Mr. Geo. H. Gooderham, chairman of the Toronto-Hamilton Highway Commission, is quoted in the daily press as having answered in the following way some criticisms directed against his action in appointing as chief engineer of the proposed highway, an engineer who is not a Canadian:

> "I received no less than three hundred applications for the position, some from engineers from Toronto and Hamilton; but there was not one among them who had the necessary qualifications for the work. Some were capable of building a 20-story building, but none were capable of laying concrete on the level."

The layman's intelligence and knowledge of present conditions is no doubt responsible for his belief that of those 300 applications the majority at least were from Canadian engineers; that the applicants felt qualified in technical ability and practical experience to undertake the responsibility of laying a concrete road, and that, considering the present prostration of engineering work, the proposed piece of construction must have attracted the attention of many of our engineers, of broad engineering experience and careful training.

It is painful, in view of the wide publicity and endorsation that has been given the whole project in the technical, trade and daily press, since its inception, that engineers of this country should be the objects of such a remark from an individual who, by virtue of his position, should know better. It points once more to the questionable silence on the part of the engineer respecting his profession and his achievements therein. His ability to lay concrete on the level should not be so conscientiously shielded from the gentle gaze of the interested public.

As for the appointee, who is also a capable engineer, it is no doubt of some little concern to him if the chairman of the commission knows as little about engineering and engineers in their relation to concrete road building as the above quotation implies.

REINFORCED-CONCRETE FACTORY BUILDINGS.

A paper to be read by F. W. Dean at the coming convention of the American Society of Mechanical Engineers (Dec. 1 to 4) presents the advantages of the use of reinforced concrete for the use of factory buildings, such as fire-resisting qualities, great window area, and good lighting, and also some of the disadvantages. It also points out that regular mill construction buildings have shown their fire-resisting qualities when properly designed. The best methods of finishing the floors are discussed and also the application of wood as a wearing floor above the concrete. The difficulties of fastening shafting hangers and machinery are brought out and the extra cost of drafting in consequence of this, as well as the great care required in making provision for everything to be installed. The different methods of constructing floors and the different forms of ceilings are taken up and also the relative costs of concrete and regular mill construction buildings.

"CO-OPERATION BETWEEN SCIENCE AND INDUSTRY."

An Open Letter to Frank Arnoldi, Esq., K.C., President of the Royal Canadian Institute.

Congratulations, sir, not so much on the addition of the word "Royal" to the title of the Institute, which in itself is no small thing, but on the goal towards which, as we now recognize, that was but a step.

"Co-operation Between Science and Industry in Canada," recently issued over your signature, will be read with interest by engineers everywhere and they will recognize and appreciate the partial return of the Institute to its old love.

The study of nature to woo from her the knowledge of her secrets is one thing and this knowledge may be called Science, or Pure Science, or Exact Science. To convert this knowledge to the use and convenience of man is another thing. It is sometimes called Applied Science, but it is really Engineering. It is the new form of the old struggle with nature to make her work for man. This struggle has been aided, has been entirely changed by the knowledge supplied by the sciences, but the knowledge is but a weapon and much lies in the wielding of it before nature is compelled to yield in usefulness. This wielding for the community is Engineering. The methods of the Engineer are scientific methods, but they are very different from the scientific methods that produced the weapons. It is Engineering that makes the weapons useful.

You are seeking methods of developing this Engineering aid. You are pleased to consider yourself neither a scientist nor an Engineer, but you belong to that profession which has a broader and at the same time a more intimate view of the real needs of the community than any other other, and you have chosen to lead back the Institute to the lines favored by its founders. The Royal Charter of 1851 stated the objects of its incorporation to be "more particularly for promoting the acquisition of those branches of knowledge which are connected with the professions of surveying, engineering and architecture." The aims of the Institute show the conventionalized symbols of Engineering and its founder was an Engineer, but for more than a generation the Institute has departed from the lines laid down for it, and the tangible results have been meagre compared with the promise of the future. Our congratulations on the return to the original trail.

Yours faithfully,

H. E. T. HAULTAIN.

C.N.R. SHOPS AT PORT MANN, B.C.

The buildings for the proposed machine shops and repair plant of the Canadian Northern Railway at Port Mann, about 16 miles from Vancouver, were completed some months ago and equipment is now being installed. The buildings are practically all of reinforced concrete construction with wood and steel roof trusses. The main erection and repair shop is 276 x 143 ft. and is laid out with two main bays. The other buildings include a 15-stall round house, a large storehouse, an 80-ft. turntable, an 80,000-gallon steel water tank mounted on a steel tower, and housing and boarding accommodation for about 150 men. The bay of the main structure devoted to repair shop has a 30-ft. elevated platform running the full length of the building to be used for purposes of light repair. Both bays are served by 10-ton travelling cranes. An electrically operated pair of jacks with spacing capacity of 25 to 45 ft. is being installed for the manipulation of locomotives. The drill, lathe and other equipment are of the most modern types.

SANITATION AND THE WAR.

At a recent meeting of the Canadian Club of Toronto, Dr. John A. Amyot, director of the Provincial Board of Health, pronounced sanitation as the most vital factor in a modern military campaign and corroborated his statement by reference to war fatalities in the past. Where efficient precautionary measures against disease had not existed, fatalities had been overwhelmingly more numerous as the result of epidemics of sickness than from the destructive forces of the enemy.

It was stated that in the South African war 12,669 men and non-commissioned officers had died from disease, while only 7,000 had died from wounds. In the American Civil War the northern army lost 102,000 men, and 20,000 of that number died from disease. Going back to the Crimean War, during 6 months, from October, 1854, to March, 1855, there were 52,000 men in the hospitals and only 3,800 of that number had been disabled by wounds.

The Russo-Japanese War very stoutly emphasized what sanitation in war meant. By rigid measures, conditions as outlined above were reversed and less than 25% of those who met death, died from disease.

The speaker pointed out the work of the Army Medical Service Corps—to keep men fit and to return as many sick and disabled persons as possible to the firing line. It was stated that before the time of antiseptic surgery the mortality in cases of amputation and injuries to lower extremities on the field of battle was as high as 90%, and that it has now been reduced to as low as 5%.

He expressed the great difficulty in the present war to be that the armies were of such a mixed nature that the difficulties attending complete sanitation on such a gigantic scale are enormous.

Dr. Amyot paid due attention to the problem of water supply and remarked that in war the army always assumed water in a new district to be impure, until it had been proved to be otherwise.

GOVERNMENT DRY DOCK AT SELKIRK, MANITOBA.

Late in October the Department of Public Works, Ottawa, completed at Selkirk, Man., the construction of a $100,000 dry dock. The capacity of the dock is 1,500 tons, and it is of sufficient size to handle a vessel 250 ft. in length. The cradle is 192 ft. long in itself, and 208 ft. over all. Its width is 52 ft. It has been constructed in two parts in order to provide for repairing two small vessels simultaneously.

The dry dock is operated by a 150 h.p. motor. By it the dock cradle is raised or lowered on a track extending 525 ft., or to any depth necessary for hoisting the craft to be repaired. The hoisting is accomplished by chains. The cradle is chiefly of steel construction, while the dock walls are both of concrete. The Crandle Engineering Co., of Boston, were the contractors. Inspection work was carried out by the Canadian Inspection Co.

Coast to Coast

Lethbridge, Alta.—The Lethbridge-Weyburn line of the C.P.R. has about 67 miles of steel still to be laid.

Woodstock, N.B.—Mr. F. T. Gutelius, general manager of the Intercolonial Railway, states that the finished portion of the Valley Railway will likely be taken over by the Intercolonial before the end of the month.

West Vancouver, B.C.—Work is progressing rapidly on the new Capilano bridge. Naylor Bros. are the contractors, and expect to have it completed early in December. This firm is also rushing to completion a new wharf at Dundarave.

Vancouver, B.C.—A large suction dredge of the Pacific Coast Dredging Co. is doing a large amount of reclamation work at Pitsilano beach. The fill, which varies from 3 to 10 ft. in depth, will aggregate about 100,000 cubic yards, and is being placed at the rate of about 3,500 cubic yards per day.

Toronto, Ont.—During the season Mr. Frank Barber, engineer for the county of York, has constructed two bridges south of Brownhill, one at Newmarket, one at Schomberg, one at Willowdale, and another on the Dawes Road, while there is one still under construction between Scarboro and Markham.

London, Ont.—Complete estimates have been prepared by engineers of the Hydro-Electric Power Commission for five different schemes of radials to connect the municipalities of Tillsonburg, Brownsville, Springfield, Port Burwell, Aylmer and Belmont with St. Thomas and London. They include buildings, equipment, and all data as to probable revenue and cost of operation.

Revelstoke, B.C.—The double track of the C.P.R. between Revelstoke and Taft, and also between Kamloops and Hapgood, each about 25 miles in length, will soon be in operation. The double-track system over the new bridges crossing the Harrison and Pitt Rivers is now in operation, giving continuous double trackage from Vancouver to Ruby Creek, a distance of 83 miles.

Edmonton, Alta.—It is stated that before the war the Alberta government acquired over $12,000,000 for use in railway construction. This sum had been received from guaranteed railway securities and had not been paid up. It is to be applied to the Canadian Northern, Canadian Northwestern, Edmonton, Dunvegan and British Columbia, Alberta and Great Waterways, and the Lacombe and Blindman Valley Railways.

Vancouver, B.C.—As announced in August 27th issue of *The Canadian Engineer* in connection with an article descriptive of the proposed Second Narrows Bridge at Vancouver, Mr. Ralph Modjeski, consulting engineer, Chicago, has been retained by the Burrard Inlet Tunnel and Bridge Co. to report on the three designs and tenders for its construction. It is expected that this report will be in the hands of the company in the course of a few days.

Winnipeg, Man.—Grading for the construction railway in connection with the Shoal Lake aqueduct was completed on November 4th to mile 9, and the remainder of the line is 75 per cent completed. Track-laying is completed for over 70 miles and ballasting for over 60 miles. In the Brokenhead River ditch 4,400 lineal feet has been constructed, resulting in considerably lowering the water level at the railway crossing. The telephone line over the entire system has been completed.

Montreal, Que.—The newly-opened Montreal branch of the Ford Motor Co. of Canada, Limited, will give employment to about 200 men. The factory has been erected at a cost of about $300,000, and covers an area of 150 x 160 ft. It is four stories in height, but has been designed to add six more stories, should the business demand it. A novel feature of the plant is the flat concrete roof, surrounded by a parapet, and to be used for testing cars after they have been assembled. The building has been designed with the view of obtaining a maximum of light for the workers.

Winnipeg, Man.—In connection with the Shoal Lake aqueduct scheme of the Greater Winnipeg Water District, a dyke 5,070 ft. in length has been constructed to divert a considerable quantity of water from the Falcon River, because of its dark color owing to muskeg effluent (see *The Canadian Engineer*, October 23rd, 1913, page 606). Since its construction the color density of the water in this section has been very noticeably reduced. On October 9th tests gave the water a color density of 186. Recently similar tests gave it a color density of 9, quite unnoticeable in a glass of water.

Vancouver, B.C.—The Pacific Great Eastern Railroad, under construction from Vancouver to Prince George, 480 miles, is in operation from North Vancouver to Whitecliffe, 12.7 miles. The line is under construction from this point to Squamish, at the head of Howe Sound, and is in operaion north of Squamish, via Cheakamus, on about 20 miles. The grading work is finished to Lillooet, 100 miles from Vancouver, and track-laying is now under way. It is expected that track-laying and ballasting on this section will be finished this year. The remaining section from Lillooet north to Prince George on the Grand Trunk Pacific is all under contract.

Pitt River, B.C.—A large reclamation scheme is now nearing completion at Pitt Meadows, in the Fraser Valley, at an expenditure of approximately $200,000. The scheme, inaugurated for agricultural and market-garden purposes, has entailed a large amount of dyking and drainage, the former necessitated by the tides which flowed over the land, and the latter by its extremely level surface. A dyke 12 miles in length, 10 ft. in height and 6 ft. wide at the top, equipped with flood-gates, key-ditch and pumping equipment, was constructed at a cost of about $100,000. The drainage work has included about 40 miles of ditching. The era of systematic dyking and drainage is beginning in British Columbia. Another scheme is under way in the municipality of Richmond, as noted in last week's issue. The lands already dyked in the Fraser River Valley are the most productive in British Columbia.

North Vancouver, B.C.—North Vancouver gets its main supply from Lynn Creek, to the north-east of the city. This supply is abundant at present, but is not absolutely reliable, fears being occasionally expressed that an exceptionally dry year or a devasting forest fire might produce a shortage in the watershed. To overcome this, the city decided upon a scheme three years ago to increase the supply by the construction of a storage reservoir at Rice Lake, the work entailing the deepening of the lake and the clearing of its banks. When finished it will have a storage capacity of about 150,000 million gallons of water. The cost is estimated at about $175,000.

At the present time the water supply from Lynn Creek comes through an intake pipe 16 in. diam., with a fall of 180 ft. to Rice Lake below it. This pipe delivers some 6¼ millions of gallons of water daily. From the lake a shaft is driven through the mountain 1,000 ft. long to connect the lake with the city system. This shaft is 6 ft. wide by 7 ft. high and has cost approximately $25,000, and through this the necessary pipes are laid, while a flume has also been constructed therein to carry away the debris from the bottom of the lake, which is being sluiced out. When a survey was taken of the lake some four years ago it was found that the bottom was covered with silt, logs and other debris to a depth of from 5 to 10 ft.

PERSONAL.

W. S. DINGMAN has been appointed water commissioner of Stratford, Ont., to succeed J. D. Barnett, resigned.

J. L. McKEE has been appointed superintendent of the St. Thomas (Ontario) division of the Michigan Central Railway.

G. C. BATEMAN, Toronto, has been appointed consulting mining engineer to the Long Lake Gold Mines, near Sudbury, Ont.

W. A. McLEAN, Engineer of Highways for Ontario, will be a speaker at the coming convention of the Union of Manitoba Municipalities, to be held at St. Boniface, November 24th, 25th and 26th.

FRANK E. LATHE, B.A., B.Sc., has been appointed lecturer in metallurgy at the University of Toronto. Mr. Lathe, who is a graduate of McGill University, Montreal, resigned a position on the technical staff of the Granby Smelter (B.C.) to accept the appointment.

J. H. BILLINGS, B.A.Sc., a graduate in mechanical engineering of the University of Toronto, was, at the outbreak of the war, on his way to Germany to take a course of study at the University of Berlin. He is now at the Massachusetts Institute of Technology taking a course for a master's degree in mechanical engineering.

A. G. CHRISTIE, B.A. Sc., has resigned his position as assistant professor of steam engineering in the University of Wisconsin to accept a similar professorship in the engineering department of Johns Hopkins University. Prof. Christie is a graduate in engineering of the University of Toronto, and is the author of a valuable series of articles on the design of central heating systems, appearing in *The Canadian Engineer* in July, 1913.

T. C. KEEFER, C.E., C.M.G., LL.D., twice president of the Canadian Society of Civil Engineers, an honorary member of the Canadian Society and the American Society of Civil Engineers and of the Institution of Civil Engineers of Great Britain, celebrated his ninety-fourth birthday on November 4th. Mr. Keefer was born in Thorold, Ontario, educated at Upper Canada College, and has had a notable and distinguished engineering career.

J. VIPOND DAVIES, Vice-President of Jacobs and Davies, Inc., Consulting Engineers of Montreal and New York, was awarded on November 3rd, by the Institution of Civil Engineers, London, England, the Telford gold medal of that Institution for his paper on the "Extensions of the Hudson River Tunnels of the Hudson and Manhattan Railroad." The Telford medal dates back to the year 1835, funds for it having been bequeathed to the Institution by the celebrated engineer, Thomas Telford, its first president (1820-1935).

AMERICAN CONCRETE INSTITUTE.

The 11th annual convention of the Institute will be held in Chicago, Ill., February 9th to 12th, 1915. This convention will mark the completion of the tenth year of the existence of the Institute, and an especially interesting and profitable program is being arranged. The sessions will be at 10 a.m., 3 p.m. and 8 p.m. The following is a summary of the program:—

Concrete Roads, Sidewalks and Bridges.—Important papers and discussions relating to the status of concrete road construction will be presented, and special attention given to costs, repairs and maintenance. (Tuesday, Feb. 9th.)

Concrete and Reinforced Concrete Tests and Design.—Discussion of the very important column tests made by the Institute at Pittsburgh, tests of buildings, and other matters of current special interest. (Wednesday, Feb. 10th.)

Concrete in Art and Architecture.—Discussion of architectural design in concrete, dimension and art concrete stone, treatment of surfaces, etc. (Thursday, Feb. 11th.)

Plant Management and Costs.—This day will be devoted to concreting plants, covering plant management and costs, the design and cost of wood and metal forms, and the methods of placing, proportioning and selection of concrete materials. (Friday, Feb. 12th.)

CHANGE IN A PROMINENT CONSULTING ENGINEERING FIRM.

Dr. J. A. L. Waddell and Mr. John Lyle Harrington announce the dissolution of the firm of Waddell and Harrington. The firm's business will be conducted as usual till the conclusion of its affairs in July, 1915, except that it is accepting no new commissions. Dr. Waddell will give his attention to special engineering and financial matters and to important advisory work. Mr. Harrington will be joined by the firm's Associate Engineers, Mr. E. E. Howard and Mr. Louis R. Ash, in the establishment of the firm of Harrington, Howard and Ash, Kansas City, Mo.

INTERNATIONAL IRRIGATION CONGRESS.

The new officers of the International Irrigation Congress are: J. B. Case, Abilene, Kan., president; Arthur Hooker, Spokane, Wash., secretary; J. S. Dennis, of Calgary, first vice-president; Richard Burges, of El Paso, Tex., second vice-president; J. F. Hinkle, of Permiston, Cal., third vice-president; Kert Grunwald, of Denver, fourth vice-president; and George A. Smith, of Salt Lake City, fifth vice-president.

COMING MEETINGS.

WASHINGTON STATE GOOD ROADS ASSOCIATION.—Convention to be held at Spokane, Wash., November 18th, 19th, and 20th. Secretary, M. D. Lechey, Alaska Building, Seattle, Wash.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.

AMERICAN ROAD BUILDERS ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.—Annual Convention to be held at the King Edward Hotel in Toronto, January 26, 27, and 28, 1915. Secretary, G. C. Keith, 32 Colborne Street, Toronto.

EIGHTH CHICAGO CEMENT SHOW.—To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.

AMERICAN WATERWORKS ASSOCIATION. — The 35th annual convention, to be held in Cincinnati, Ohio, May 10th to 14th, 1915. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—Annual meeting to be held at the Iowa State College, Ames, Iowa, June 22nd to 25th, 1915. Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Volume 27. Toronto, November 26, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

ST. PAUL STREET BRIDGE, ST. CATHARINES

NOTES ON THE DESIGN OF FOUNDATIONS AND SUPERSTRUCTURE OF THE PROPOSED STEEL HIGH LEVEL VIADUCT FOR WHICH CONTRACTS ARE NOW BEING LET.

By H. C. TAYLOR,
City Engineer's Office, St. Catharines.

THE substructure is under way and tenders have been called for the superstructure of a steel viaduct 1,236 ft. 3½ inches in length to provide a better means of communication between the business centre of the city of St. Catharines and the section known as the Western Hill. The only steam railway entering the city is the Grand Trunk, and its station and freight sheds are also situated on Western Hill. A deep valley intervenes, through which extends the old Welland Canal.

The need of a high level bridge has been a subject of controversy for a quarter of a century, and several campaigns were started at different times by private enterprise to provide funds for its construction. No definite action was taken by the city itself, however, until shortly after the outbreak of European hostilities, when, in the face of an indefinite period of monetary stringency, a by-law was passed by the ratepayers authorizing its immediate construction.

Of the several possible routes the St. Paul St. extension was finally chosen as being in the best interests of the city. A very slight deviation of the street alignment was necessary, and the structure at the same street level, as proposed, is made to provide for the elimination of 80 ft. of heavy grades with which the present roundabout road to the station is handicapped.

Several designs for the contemplated structure were submitted by Messrs. Sprague and Reppert, consulting civil engineers, Pittsburgh, Pa. Fig. 1 shows the type selected. In the test borings on the site no rock was found nearer the surface than 85 ft. There was also a matter of $40,000 difference between this design and an alternative one of concrete construction. Both factors figured materially in the selection of a steel structure. The cost of the bridge is estimated at $165,000, while the right-of-way has been purchased by the city for $55,000. Against this there are two grants, one from the Dominion Government amounting to $50,000 and one from the Grand Trunk Railway to the amount of $20,000; making a net cost to the city of $150,000. Preliminary work has included, in addition to the above, the cost of removing four stores and three large houses from the site of the north approach to the bridge. A new street will be made, and, when the structure is completed, there will be two

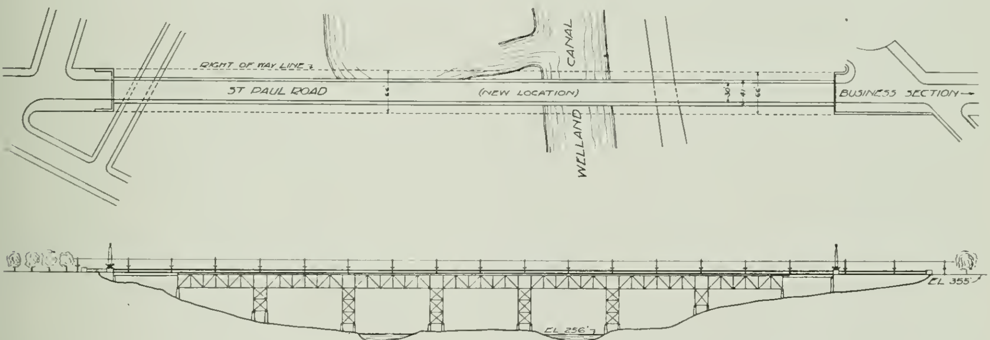


Fig. 1.—General Plan and Elevation of the Proposed Bridge.

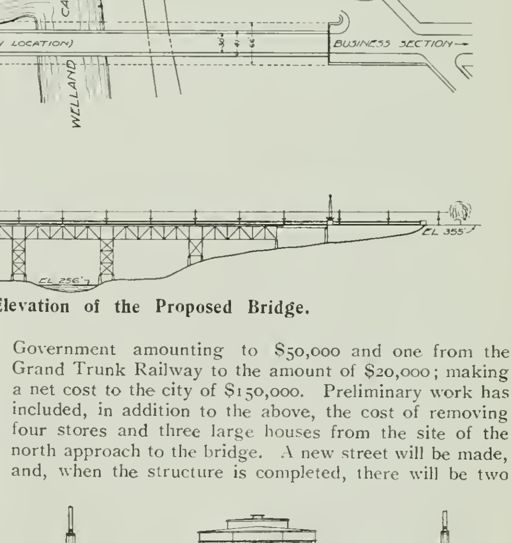


Fig. 2.—Section of Roadway.

streets leading directly to the bridge at the north end, thus allowing for future extension of traffic.

Contracts are being let in three sections. The substructure has already been let by contract to Campbell &

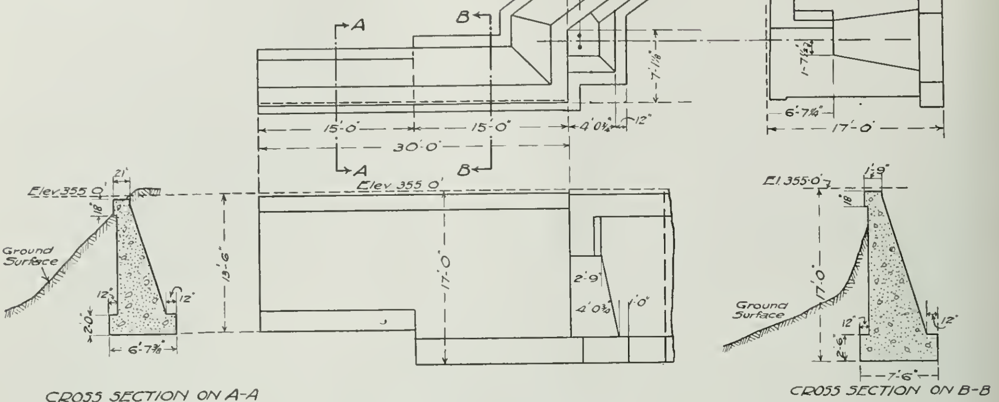


Fig. 3.—Details of Wall Section No. 1.

Lattimore, Toronto. Tenders for the steel superstructure close on December 8th. The contract for paving, which will probably be of creosoted wood block, will be let at a later date.

The work in connection with the substructure consists of about 3,000 cubic yards of excavation, and 1,850 cubic yards of concrete in piers and abutments. There will also be considerable concreting in copings and parapet wall. About 10,240 lineal ft. of timber is being used in piling. Other quantities of interest include 7,250 pounds of anchor bolts and 3,000 pounds of reinforcing steel for the piers and abutments. The contract for this work has

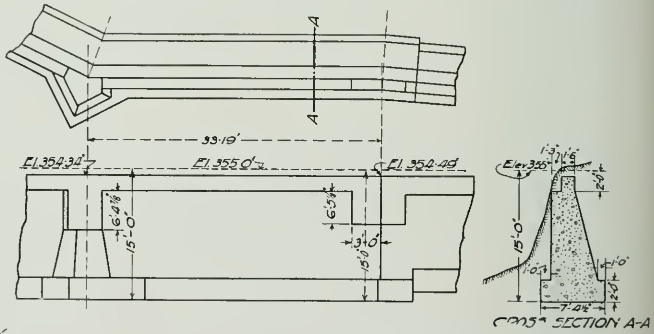


Fig. 4.—Detail of Wall Section No. 3.

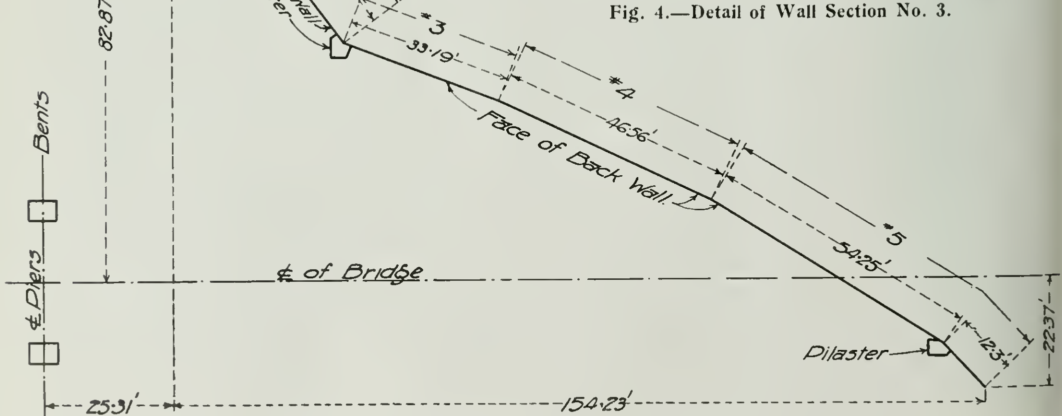


Fig. 5.—Location Diagram of Wall at North Approach.

been let at an amount about $10,000 under the engineer's estimate, the latter being based on normal conditions.

The design of the north abutment possesses some points of considerable interest. As shown in Fig. 5, the wall has been divided into sections with alignments at angles to the centre line of the bridge. Section 1, 30 ft. in length, marking the extreme end of the abutment along Yates St., is shown in detail in Fig. 3. It varies in height from 13½ ft. to 17 ft., and includes a pilaster at the intersection with wall section No. 2. Section No. 3, the details of which are shown in Fig. 4, which is 33.19 ft. in length, is uniform in depth, 15 ft., and its section corresponds to section BB′ in dimensions. In section 4, 46.56 ft. long, the height decreases owing to an elevation of 2 ft. of the base, while the thickness of the base of the retaining wall decreases with the height to 6 ft. 10½ in. Wall section No. 5, which is illustrated in Fig. 6, is 54.25 ft. long with a depression of the base to 15 ft. and a corresponding enlargement of the base to 7 ft. 4½ in. in width, as shown in Fig. 5. The centre line of the bridge is crossed by this wall section, and a pilaster, shown in Fig. 6, connects a sub-section 12 ft. 3 in. in length, which forms the extremity of the abutment wall.

The south abutment, 24½ ft. in length, is shown in Fig. 7, which illustrates clearly the general features of its design and the proportioning of the supporting walls.

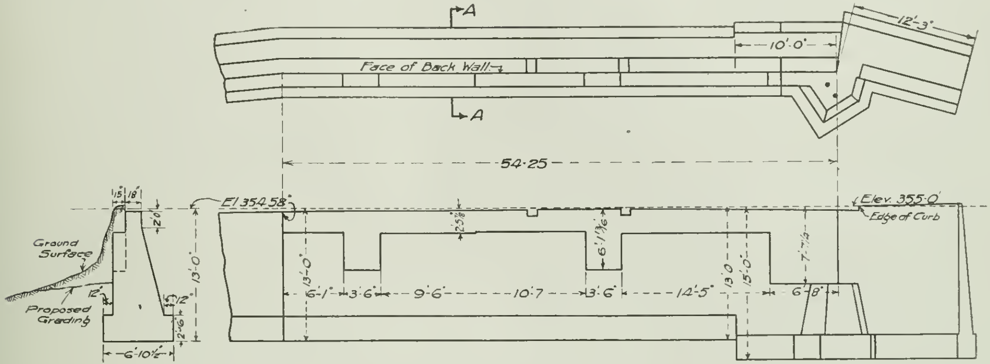


Fig. 6.—Details of Wall Section No. 5.

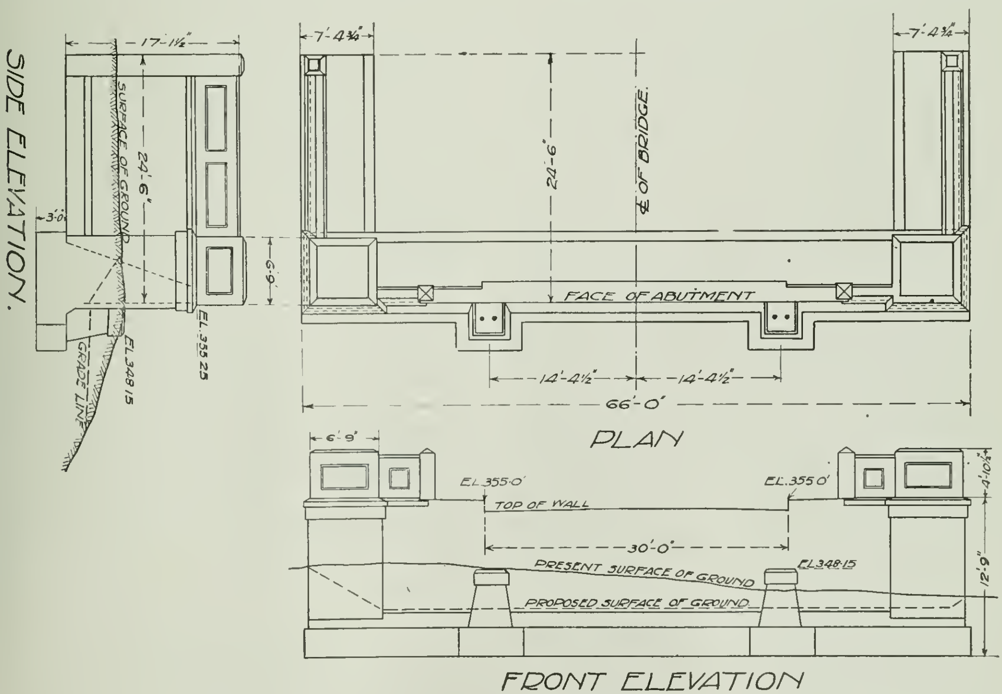


Fig. 7.—General Design of South Abutment.

There will be seven Warren truss spans, with plate girders at the ends extending to the concrete approaches. The steel is supported on 35 concrete piers, two for each of 17 bents, and a single pier at the south end. Five of these piers are reinforced. The 8 bents on the level portion of the valley rest on timber piles driven to a depth of about 40 ft., or to a point where each pile will sustain a load of at least 30,000 pounds. There are 16 piles to each pier, the piers being 12 ft. square at the base, with the piles spaced 3 ft. c. to c. both ways, and 18 inches in from the edge, the point of cut-off being 6 inches above the bottom of the pier. The bents adjacent to the canal banks are to be sheeted with 3-inch tongued and grooved material, driven to a depth of at least 6 ft. below the bed of the canal, the sheeting to remain in place and to be cut off 1 ft. below water level. The 4 anchor bolts for each pier are to be placed by means of a templet. This is a part of the work that requires accuracy and carefulness, as the steel will be ordered some time before the completion of the substructure.

As illustrated in Fig. 2, the bridge has been designed for a single-track electric railway, a 30-ft. roadway, and two 5-ft. sidewalks. The members are designed to carry a 36-ton car.

It is expected that the completed structure will be open to traffic in the fall of 1915. Mr. W. P. Near is the city engineer.

FIELDS FOR THE INDUSTRIAL APPLICATION OF CANADIAN WATER POWERS.

SOME very potent arguments bearing upon Canadian water powers and the rate at which they are being made of service to the country were presented at a meeting of the electrical section of the Canadian Society of Civil Engineers in Montreal, November 16th, 1914. A paper entitled "Making Our Water Powers Valuable" was read by Mr. Arthur Surveyer, consulting engineer, Montreal. It dealt chiefly with the position Canada holds in respect to other countries and presented in their true light the possibilities which exist and the national asset which we have in our water falls as a guarantee of future industrial superiority.

The paper presents a concise history of the harnessing of the larger and higher water falls by the modern turbine, in various countries, the first development of this sort in America being a 15,000 h.p. plant constructed at Niagara Falls in 1893. It alludes to the wonderful progress made in the technics of hydro-electric work since that time, to the recent improvements in installation which have made possible the economical transmission of energy for distances of 200 miles and over, and to the improvement of the modern turbine whereby low head developments are now commercially feasible. It compares the water powers of different countries and shows that Canada is not the wealthiest in water powers, especially if provinces are compared with countries of similar area, for example France, Austria, Sweden and Norway. The truth is brought out that although the available horsepower per square mile is greater in some cases, we are woefully behind other nations in the percentage of utilization. The following table indicates the uses made of hydro-electric energy generated in Ontario, Quebec, France, Sweden and Norway, and shows that up to the present we have only progressed in the simpler applications of electricity. It shows also that we have somewhat neglected its utilization as an electrolytic agent and as a heat-generating agent in electro-chemistry and electrometallurgy.

Countries.	Developed hydro-electric power.	Subdivision of developed power. Electro-chemistry and electro-metallurgy.		Motive power, traction and lighting.	
	h.p.	h.p.	%	h.p.	%
France . . .	592,000	291,000	49.1	301,000	50.9
Norway . .	543,000	275,000	50.6	268,000	49.4
Sweden. . .	370,000	120,000	32.4	250,000	67.6
Ontario. . .	320,000	25,000	7.8	295,000	92.2
Quebec . . .	198,000	28,000	14.1	170,000	85.9

In discussing ways and means for the advantageous alteration of these conditions, the author refers to the consumption of electricity for lighting and for traction as dependent on population, and notes that the consumption of electricity per capita for either lighting or traction is too small to be considered as an inducement for the extensive development of our water falls. The pulp and paper industries are referred to as large users of power and in this instance Canada is not so very far behind, although Sweden utilizes over 120,000 h.p. in this manner.

The author emphasizes the value of closer attention to electro-chemical and electro-metallurgical industries which would require a notable increase in the development of our water powers. He briefly reviews some of these industries that either on account of the abundance of necessary raw materials or because of large neighboring markets, might be likely to prosper in this country.

Electro-chemical Industries.—The manufacture of calcium carbide is the oldest of these industries in Canada. Three plants are in operation at present, absorbing about 14,000 h.p. and producing about 12,000 tons annually, half of which is exported. (The world's production in 1913 amounted to 339,000 tons.) The Canadian Carbide Co., with a capital of $2,000,000, control these three plants, one at Thorold, Ont., of 1,000 tons capacity, one at Ottawa, producing over 4,000 tons, and one at Shawinigan Falls, Que., supplying about 7,000 tons, annually.

There are also the nitrogenized fertilizers all except one process of which utilize electrical energy to combine directly the atmospheric oxygen and nitrogen. This combination gives nitric acid which in presence of water and air in excess is transformed immediately to nitrous and nitric acid and finally into nitric acid only; this azotic is either sold as such or is led over limestone, giving as final product the nitrate of lime which is utilized in place of the Chili saltpetre or nitrate of soda for all agricultural uses.

"The story of the fixation of atmospheric nitrogen can be summed up as follows: In 1902, the Atmospheric Product Company erected in Niagara Falls a trial plant for the manufacture of nitric acid by the Bradley and Lovejoy process. During the same year, de Kowalsky began in Fribourg a series of researches which were continued by Moscicki and led to the erection of a trial station at Vevey, in Switzerland; in 1903, Professor Birkeland, of Christiania, discovered a new process which was afterwards perfected by Birkeland and Eyde, and is now applied on a very large scale at Notodden in Norway. In 1903, also, Frank and Caro made public a new method of fixation based on a different principle and giving calcium cyanamide as the final product. More recently, Pauling and Schonnherr have taken out patents for other processes."

Nitrate of lime has developed in production since 1909 to 110,000 tons last year. For this industry alone the Norwegian Nitrogen Co. have undertaken the construction of plants with the total capacity of 540,000 h.p Nitric acid is produced in quantities ranging from 200,000

to 250,000 tons per year, United States producing about 70,000 tons. The margin between the selling price of ordinary nitric acid and the cost of synthetic azotic acid is large, according to Mr. Surveyer, and indicates that this industry can afford to pay even more than the nitrate plants for its electrical energy.

Calcium cyanamide requires electrical energy in its production. The world's output in 1913 was 226,000 tons. The Canadian plant of the American Cyanamide Co. at Niagara Falls began operation in 1910 with an output of 10,000 tons. The capacity has since been increased to 24,000 tons per year.

Electro-metallurgy.—In dealing with the industries to which hydro-electric power is applicable under this heading, the writer refers to aluminum, the first metal manufactured in a hydro-electric plant, as belonging to electrochemistry on account of the electrolytic method employed and to electric metallurgy on account of the nature of the product. He traces the growth of its manufacture and the enormous reduction in price per pound which it has experienced. In 1912 the United States produced 18,000 tons of aluminum, France 13,000 tons and Canada 9,000 tons. The actual capacity at present of the plants of the Aluminum Company of America is 90,000 h.p. This company has recently signed a contract with the Cedars Rapids Power Manufacturing Co. for the purchase of 60,000 h.p. to be used at their Massena plant on the St. Lawrence. The Shawinigan plant is the property of the Northern Aluminum Company, and has a capacity of 20,000 h.p.

Nickel, zinc and copper are also referred to as minerals extracted from their ores by smelting in the electric furnace. There is a great field for development of the Canadian industry with respect to them.

The production in the electric furnace of pig iron, ferro-silicon, ferro-titanium, and of steel is lengthily considered. The world's production of pig iron by this method was approximately 25,000 tons in 1912. Extensive experiments have extended over the past several years in Sweden. In Scandinavia there are 20 furnaces absorbing over 36,000 h.p. The world's production of ferro-silicon is over 60,000 tons per year. Two Canadian companies are manufacturing it, the Lake Superior Power Co., at Sault Ste. Marie, with an electric furnace of 250 h.p., and the Electric Metals Co., at Welland, with 4 furnaces totalling 5,000 h.p. Ferro-titanium is worthy of interesting study on account of the large deposits of titanium ore in the province of Quebec.

In the production of electric furnace steel 120 furnaces turned out 175,000 tons in 1912. The electric furnace is also extensively used for melting steel for castings. (Although not mentioned in the paper, it is worthy of note that the Moffat-Irving Steel Works, Limited, Toronto, have a furnace now in operation for the direct production of steel castings or ingots. The furnace is of the 3-phase type, and of 300 kw. This furnace was described in *The Canadian Engineer* for October 23rd, 1913.)

The different industries enumerated by Mr. Surveyer absorb approximately 1,500,000 h.p. Canada's contribution to this enormous utilization of power is just about 3.5% of the total.

Some Foreign Opinions.—After giving a brief survey of the large field which is open and worthy of utmost diligence in study, the paper reverts to some opinions of foreign engineers respecting the future for these industries in Canada. The existing obstacles have been well sifted out, and are, in particular, (1) The severity of winter, causing a low-water period; (2) Absence of adequate means of transportation; (3) Unlikelihood of enlarging Canadian Works around Niagara Falls, owing to movements on foot for conserving the beauty of the water power. While these criticisms are partly correct and while we are in a measure handicapped with economical, educational and physical obstacles to a rapid development of our water powers, it is inspiring to note the extensive studies that are being made by the Department of the Interior, Department of Public Works, Hydro-Electric Power Commission of Ontario, and the Quebec Streams Commission.

With respect to the attracting of foreign capital we quote the following from Mr. Surveyer's paper:—

"It is safe to say to-day, that through the lack of surveys, of discharge measurements and of gauge readings there are very few of our water falls which could be offered to oversea bankers. To convince these men we must be able to lay before their technical advisers, complete plans to enable them to make in their office a rough estimate of the first development costs; we must, moreover, show them discharge measurements and gauge readings covering a sufficient number of years to allow them to calculate with accuracy not only the minimum power available, but also the average power on which they could depend. The electro-chemical and electrometallurgical industries require energy at such moderate rates that it would be impossible in most cases to bank on the lowest available power only. These industries must have the help of the periodical power to lower the average cost of the energy utilized during the year."

In concluding, the writer refers to the serious handicap which the development of our water powers has experienced owing to the difficulty of obtaining a clear title of ownership, and to the lack of commerciality of some of the clauses contained in government leases. He urges a separate water power policy for each province.

DUSTLESS STREET CLEANING.

Canada's climatic conditions, to a certain extent peculiar to herself, impose handicaps in the care of pavements which are hard to overcome.

The dust on business streets is the admitted cause of immense damage to stocks of merchandise and also is very disagreeable to the individual. This is especially so in early spring and late autumn, when the water sprinkled on the pavements freezes, resulting in accidents to horses and pedestrians.

Water used on pavements at such times is also the cause of serious damage to them, as it soaks into the crevices in the pavement, and freezing, causes the upheaval and disintegration of the pavement. This is especially noticeable along the curbs and street car lines.

Dustless street cleaners, operated on the combined vacuum and sweeper principle, are in use in a number of North American cities. It is claimed that their work is entirely satisfactory, that after cleaning, no sprinkling is necessary, as the dust has been thoroughly removed. The advantages of this system are numerous, including the absence of the dust nuisance, resulting in conservation of both health and property; the saving of water and a large percentage of the cost of sprinkling; the saving of labor in street cleaning, and the avoidance of damage done by water to pavements in frosty weather.

PRINCIPLES COVERING DESIGN OF INBOUND AND OUTBOUND FREIGHT HOUSES.

THE economical handling of less-than-carload freight at terminals is a problem that is giving a great deal of concern. The cost of handling a ton of freight a mile by train is approximately known, but it is almost impossible to figure the cost per ton mile for trucking and handling of unclassified freight at the freight house. The cost of terminal handling in all cities is so great compared with the cost of moving a train or a vessel when started on its journey that the latter can be ignored. Freight house design should receive serious consideration. In this connection much of interest and value will be found in the following principles adopted this year by the American Railway Engineering Association and appearing in the recently issued supplement to the 1914 manual.

In outlying districts, where fire hazard is not great and business is not large, and the building laws will permit, frame freight houses having wood floors on joists, studding covered with wood sheathing or metal siding, and wood rafters and sheathing covered with appropriate roofing, are fairly satisfactory and cost less than any other type. Floor for this type should ordinarily be designed to carry 250 lbs. per sq. ft.

With such construction there should be ventilation beneath the floor, but access to the space under the house should be prevented to avoid the accumulation of rubbish and increased fire hazard.

But even where a frame house is to be used, it is better practice to use a fill between concrete foundation walls, eliminating some fire hazard and decreasing maintenance charges.

Where the laws prohibit frame structures and the value of freight stored is considerable and it is necessary to build freight houses of so-called fireproof material, floors should be placed on a fill between foundation walls, and the exterior walls should be of masonry or steel frame covered with metal siding. Roof trusses, framing, etc., can be of wood, covered with appropriate roofing, but to provide better fire protection fireproof construction should be used.

Fire walls of brick or other non-combustible material should be located so as to conform to the requirements of the underwriters. The strictest practice limits the area between fire walls to 5,000 sq. ft. This especially applies to houses with no outside platform. In wide houses, this locates the walls rather close together for economical operation. Fire walls should in no case be more than 200 ft. apart.

Doors in fire walls should be as limited in number as possible, no one door opening should exceed in area 80 sq. ft., and all should be equipped with automatic fire doors.

Where non-fireproof construction is used in inflammable parts, the structure should be covered with fireproof material for a distance of at least 5 ft. on either side of the fire wall. This refers especially to overhanging roofs.

Where but a single house is needed, a width of from 30 to 40 ft. is good practice.

When the amount of freight handled is sufficient to justify it, separate houses for inbound and outbound freight are desirable. When these are provided, the outbound house should be narrow, not more than 30 ft. wide, and the inbound 40 to 70 ft. wide, it being considered expensive operation where a house is in excess of 70 ft. in width.

A platform 8 to 10 ft. wide, along the track side of the house, avoids the necessity of considering the location of doors in spotting cars on the track next to the house, and also eliminates the necessity of keeping an aisle-way inside the house on the track side. It should be at least 8 ft. wide, to give sufficient room for two trucks to pass.

The distance from the centre of the nearest track to the face of the platform or freight house should be not less than 5 ft. 9 in. where tracks are on tangents.

The top of rail should be 4 ft. below the floor or platform level at the track edge, where refrigerator cars are not to be handled in any quantity. With occasional refrigerator cars, the doors can be opened before the cars are set.

Where refrigerator cars are to be handled regularly, the height should not be more than 3 ft. 8 in., this conforming to the recommendations of the M. C. B. Association. The alternative of spacing tracks at least 7 ft. from platforms is usually expensive at important terminals. Many roads are building cars that are lower than the maximum figures given above, and each road in deciding the height of platform above the top of rail should take into consideration the sizes of cars that predominate on its line.

The platform should be protected by an overhanging roof, not greater than the width of the platform, and at least 10 ft. above the platform level.

Where state laws permit, protection over the cars is often used. This should be at least 17 ft. above the top of rail and should preferably extend to within 18 in. of the middle of the car. This will allow walking on the top of cars.

There should also be an overhanging roof or other protection on the team side to protect goods while being unloaded, the overhang to be at least 4 ft. and preferably more, 12 ft. being needed to give protection from a driving rain.

Freight houses without outside platforms would seem desirable in some localities, especially in northern climates, where there is considerable snow and sleet, as these houses can be entirely closed, except for that part of the house where the freight is being received or loaded. At some points where ample track room is not available, the elimination of the outside platform gives better results.

With this type it is necessary to leave more trucking space inside the house longitudinally the full length of the building. With the house congested with freight, it is difficult to keep the aisle-ways from being crowded up so that it is almost impossible to get through with a truck that is loaded with large packages. This causes delay and confusion.

On the street side, the floor of the inbound house should be from 3 to 4 ft. above the street grade, depending on the type of trucks in use. At the outbound house the height should not exceed 3 ft.

To assist trucks, the floor of the inbound house should be sloped toward the street, approximately 1 in in 8 ft., this being for the house proper. An outside platform on the track side should slope approximately 1 in. toward the tracks for draining.

For the outbound house, the floor should slope from the street to the edge of the platform alongside of the car not more than 1 in. in 8 ft.

Several kinds of doors are satisfactory, counterbalance lift (either folding or not), rolling shutters and parallel sliding.

It is advantageous to have as much door opening on the team side as possible. And with all types of doors

except the last, all of the house can be opened except for the space occupied by posts.

With the parallel sliding doors, not more than half of the space can be opened up. They are satisfactory on the track side.

Without the outside platform continuous doors should be used, so that an opening can be obtained at any point opposite a car door.

Where an outside platform is provided, a door in each panel is sufficient. Considering the average length of cars and economy in framing, 22 ft. is a good panel length.

It is advantageous to have the floor entirely free from posts; but in houses approaching 50 ft. in width the saving made by using posts becomes considerable and great enough to offset the advantages due to their omission.

On account of light weight merchandise being piled high on trucks, it is desirable to have the edge of the eaves at least 14 ft. above the level of the driveway, where local conditions will permit.

As all freight trucked into the house and cars must pass through the car door, the height of the freight-house door need be little greater than the car door. All doors should be at least 8 ft. high. On the team side a greater height might at times be convenient.

Natural light should preferably be provided in the side walls above the doors. Skylights in the roof are expensive to maintain and ineffective, as is also glass in canopies, or on any plane approaching the horizontal.

Artificial light is needed for operation at night and during the late afternoon in the winter, and, wherever possible, electricity should be used, with wires run according to the specifications of the National Board of Underwriters. One or more lines of lights should be run the full length, inside the house, and one line over outside platforms.

Another circuit should be run along the face of the platform wall, parallel to the track, with outlet boxes not over 40 ft. on centres, with socket arrangement for push plug for use in attaching an extension cord to hang inside the car to provide light for loading on dark days and evenings during the winter season. The need of other outside lights on the train side is questionable.

The type of lights will depend somewhat on the height of the ceiling. All lights should be stationary and operated in circuits from conveniently located panelboards. The circuits should be carefully planned, so as to allow maximum economy in use of lights.

Where water pressure is available there should be provided for fighting fire, standpipes and hose racks not more than 150 ft. apart. By putting them on the fire and end walls they are thought to be more accessible and less liable to be blocked by freight than if located at other points, but by putting them about 40 ft. from the end of each section, fewer hose connections are necessary to cover the entire station. By putting them 100 ft. apart, 50 ft. of hose will be sufficient for each connection, more than this being somewhat inconvenient to handle. As there is no heat in the house, the valve controlling the water supply should be located below the frost line and controlled by a stem, with a hand wheel above the floor. The valve should be located in a pit, so as to be readily accessible for repair or renewal. It should be drained into the pit, and this in turn be connected to the sewer. A 2½-in. standpipe of wrought-iron should be run up to approximately 8 ft. above the floor, and to this should be attached a hose rack, equipped with 50 ft. of 2-in. rubber-lined linen hose.

In houses where electricity is available, there should be over each hose rack a small red light to designate the location of the fire-fighting apparatus, this light to be kept burning at all times.

Chemical extinguishers should be provided in addition to the hose and standpipes. As they are put out of service by freezing, some provision should be made for replacing them or keeping them warm. Tanks containing a solution of calcium chloride are used successfully.

Where a watchman is needed, a watchman's clock system, with a registering clock in the freight office and stations located at various places throughout the freight houses, should be installed.

In outbound houses sufficient scales should be provided so that all the freight can be weighed. From 50 to 80 ft. apart is good practice. In inbound houses where little of the freight is weighed, scales should be placed at least one in each section. The scales should have a minimum capacity of four tons. A successful dial scale expedites the handling of freight. Stalls for checkers should be located at least one in each section. These should be approximately 4 ft. 6 in. by 4 ft. 6 in., with a shelf along the back and drawers beneath. Sometimes they are left entirely open in front, and sometimes are closed up, and heated, depending on local conditions. Some roads make their checkers' stalls portable, so as to allow them to be moved in case of a special congestion of freight at certain points, but this is not ordinarily considered necessary.

In inbound houses a room should be provided to house "over, short and damaged" freight; this to be enclosed so that it can be kept locked.

In large layouts, particularly where there is considerable transfer business, a room should be provided for repairing broken packages, such as crates, boxes, barrels, etc.

In large houses a separate office should be provided for the foreman. If this can be an elevated structure, it will save floor space.

In large houses the general office for the clerks and the private office for the agent should be provided by a second story over the inbound house, and in the second story should also be a space for files and stationery cases, toilets asd locker facilities for clerks. This all should as far as possible be in view from the desks of the agent or chief clerk. The cashier and his clerk should ordinarily be located on the first floor.

Where possible, it is preferable to have the clerks' and agent's offices, the toilet rooms, etc., for the freight handlers and draymen, the room for "over, short and damaged" freight, and the cooperage room for repairing broken packages, etc., all in one section. In the larger terminals provision may be wanted to care for perishable freight, and when it is provided, it should also be located in this section.

The basement should house the heating plant, with room for coal, and is sometimes a good place for toilets for the freight handlers and draymen, and for locker and lunch rooms for the freight handlers.

Where both outbound and inbound houses are arranged in the same layout, a transfer platform is usually included. One of the best designs for covering these platforms is a butterfly shed, with the posts located in the centre of the platform. Where this design is used, the platform should not be less than 12 ft. wide, to provide room for trucks between the posts and the cars.

For loading and unloading agricultural implements and other large, bulky packages, platforms should be built, usually as extensions to the inbound and outbound houses, with ramps on the ends of the platforms. The

extension platform should be at least 8 ft. wide, and if possible, 16 ft. wide, especially if covered. A stub end track butting against a platform with a ramp is valuable.

Where no gantry crane is provided in the freight yard, a stiff leg or pillar crane should be provided on the end of the extension platform.

It is not good practice to put downspouts inside the house, and in placing them outside they should be properly protected.

On the team side of all freight houses a fender should be provided to protect the walls from the wagon wheels. A good type is one made up of an 8-in. by 10-in. timber set on brackets, with a spacer or separator to keep the timber approximately 2 in. away from the wall, so that dirt will filter through and not collect on the fender.

In large cities it is frequently advisable to build the inbound houses eight to ten stories high, using the ground floor for handling freight and the balance of the structure for storage, to be leased to shippers. Most of the material stored will not be affected by heat or cold, but provision should be made for cold and warm storage where conditions warrant.

GERMAN SUBMARINES.

The enemy's submarine is comprised of two classes. The Krupp submarine is of the following typical dimensions: Length 120 ft., beam 12 ft., depth 12 ft. 6 in., surface displacement 225 tons, submerged 280 tons. The vessel has an inner and outer hull. The outer hull has the lines of a torpedo boat with high freeboard forward to give seaworthiness. The inner hull is built up of three circular welded sections bolted together. The space between the two skins is divided up into ballast and fuel tanks.

Surface propulsion is effected by two sets of 4-cylinder vertical petrol motors developing 440 h.p. For submerged work two electric motors developing 250 h.p. are used. The conning tower contains all the devices for steering, submerging and working the boat. There are two torpedo tubes in the hull and one mounted on deck aft.

In the Lake type, heavy Diesel engines are used for surface work. These motors are from 200 to 220 h.p., and for under-water work electric motors are used. Special ventilating arrangements are provided. When submerged the vitiated air is drawn off and passed through various filters, oxygenated and cooled. By this means the craft can stay under water for twenty-four hours. The electric accumulator apartments are hermetically sealed to prevent the escape of poisonous gases. Two periscopes are carried, the tubes of which are 16 ft. 6 in. in length. The water ballast tanks can be emptied by means of compressed air in a very short time. The outer hull is fitted with shackles to facilitate salvage operations. A telephone wire is carried to communicate with the outside world, the outer end of the line being attached to a buoy which can be released automatically.

The later submarines of the German navy are said to be over 800 tons in displacement and capable of a speed of 16 knots on the surface, with a corresponding underwater speed of 8 knots. They are fitted with 18-in. torpedo tubes, submarine signalling apparatus, searchlights and small disappearing guns.

The city of Calgary is finding it more economical to shut down one of its incinerators and to operate the other 24 hours a day, on 8-hour shifts.

POLES AND CROSS-TIES IN 1913.

The Forestry Branch, Department of the Interior, has just issued a bulletin, compiled by R. G. Lewis, B.Sc.F., in which are tabled the purchases of poles and cross-ties in the Dominion during 1913. The former relate to 424 pole purchasers consisting of 218 telephone companies, 155 electric light and power concerns, 29 electric railways, 18 steam railways and 4 telegraph companies. For convenience the writer divides them into two main groups: (1) Steam railway, telegraph and telephone companies, and (2) electric railway, power and light concerns. The information relating to cross-ties is collected from the different railway companies of Canada, steam and electric, both jointly and separately. Reports were received from 47 steam railways and 32 electric railways.

In 1913 from a total of 534,592 poles, 49.4 per cent. were white cedar; 27.2 per cent. red cedar; 21.6 per cent. tamarack, while 1 per cent. or less of each of spruce, jack pine, balsam fir and white pine was recorded. Of this amount 469,521 poles were purchased by steam railways, telephone and telegraph companies, and 65,071 by electric railways, power and light companies.

Of the total 340,865 poles, or 63.8 per cent. were 20 to 25 ft. in length; 21.8 per cent. were 26 to 30 ft. in length; 7.1 per cent., 31 to 35 ft.; 4.4 per cent. 36 to 40 ft., and 2.9 per cent. 40 ft. or over. Of poles under 25 ft. in length, over 97 per cent. belong to the two cedar species and eastern tamarack.

As against 534,592 poles purchased in 1913, there were 608,556 poles purchased in 1912.

A total of 19,881,714 cross-ties were purchased in 1913 as against 21,308,571 in 1912. Of these 39.1 per cent. were jack pine; 12.3 per cent. white cedar; 12.2 per cent. Douglas fir; 6.2 per cent. western larch; 6 per cent. hemlock; 5.7 per cent. hard pine; 4.9 per cent. oak; 4.4 per cent. tamarack, and smaller percentages of western hemlock, spruce, chestnut, red cedar, red pine, beech, birch, maple, elm, ash and cherry. Electric railways used 391,233 of these.

The average value of poles of all kinds was $2.22 each, and of cross-ties 43c. each. A total value of $1,188,331 is accorded to poles, and $8,740,849 to cross-ties.

In Canada in 1913 about 10 per cent. of the cross-ties purchased by both classes of railways were given a preservative treatment to retard decay.

PRODUCER GAS PLANTS IN THE UNITED STATES.

The total horse-power of gas-producer power plants in the United States was 160,000 in 1911, of which 80,000 was obtained from bituminous coal, 70,000 from anthracite and 10,000 from lignite. The cost of producer-gas installations is about equal to that of reciprocating steam engines; the cost of maintenance is only about one-half, while the economy has been shown in several cases to be 2 to 3 times as great. The heat losses in typical steam and gas plants are given in the following table:—

	Steam plant.	Gas plant.
Heat lost in ashes	2.00	1.10
" " radiation and cooling	4.60	18.60
Heat lost in smoke	24.60	.....
" " radiation and friction	3.30	4.30
Heat lost in exhaust	53.50	23.70
" " jacket water	.....	33.50
" " auxiliaries	7.30	.....
Total losses in entire plant	95.30	81.20
Net efficiency of plant	4.70	18.80

AN EMPIRICAL FORMULA FOR THE DESIGN OF RETAINING WALLS.

Retaining Walls Backed With Earth to the Top of the Wall.

By C. P. Symonds.

WRITERS about these retaining walls give formulæ and rules requiring the weight per foot of the brick-work, and of the earth behind it. Bricks in one district may be light, and those in another may be heavy; though they may both be good, well made, and well burnt; therefore, their weight is a doubtful ele-

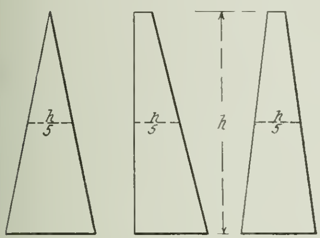


Fig. 1.

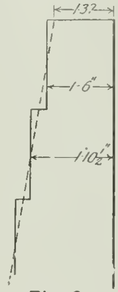


Fig. 2.

ment in calculation. And the earth behind the wall may be wet clay, dry earth, loose sand, or of varying composition, so that its weight is another uncertainty. Again, the backing is almost always heaped up behind the wall soon after it is built, and before the mortar is set.

Therefore engineers in England have, from practical experience, formed a general rule based upon the average thickness compared with the height of the wall. Thus,

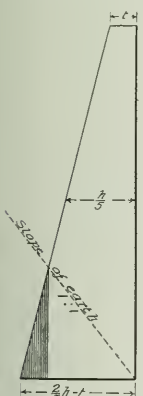


Fig. 3.

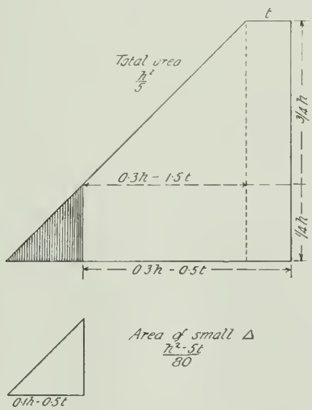


Fig. 4.

in a wall battering ⅛ of the height or 1½ inches in a foot, the average thickness of the wall is to be 1/5 of the height; in such case putting h for the height of the wall the average thickness will be $h/5$, and the area of the cross-section will be $\frac{h^2}{5}$. The section of the wall may be any of the shapes shown in Fig. 1, keeping the average thickness $h/5$.

In the following I have taken the top of the wall as 18 inches and the back of the wall is set off in steps of 4½ inches (Fig. 2). For an average line (dotted) for calculation, the thickness of the wall at the top is taken as 1.32 feet, this being an average line between 1 ft. 6 in. and 1 ft. 10½ in. Then, given h for height and t for thickness, keeping the average thickness of the wall 1/5 of h, the section of the wall will be as in Fig. 3.

Ordinary earth protected from the weather will stand at an angle of 45° or a slope of 1 : 1. It is evident, therefore, that the small shaded triangle is not wanted for supporting the earth, and may be cut off. But, as the height of this triangle varies with every height of the wall, it would complicate the calculations. I therefore take the height of this small triangle as ¼ of the height of the wall, or $\frac{h}{4}$ as a constant quantity, which is a close approximation and greatly simplifies the work. An ex-

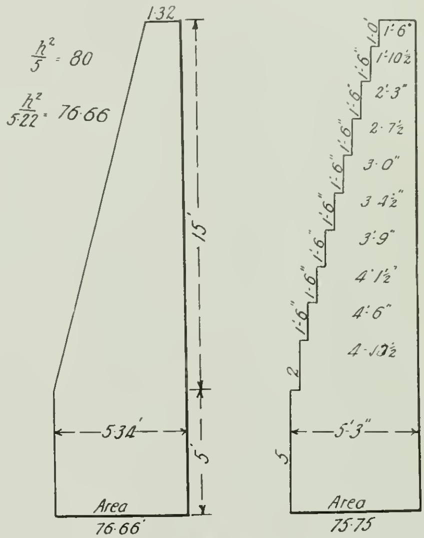


Fig. 5.

aggerated section will then be as in Fig. 4, and after deducting the area of the small triangle, the final area of the wall will be $\frac{3h^2 + ht}{16}$. If the foundation is not good, leave in this small triangle, but if good it may be cut off.

In the two diagrams in Fig. 5, the left-hand one is the calculated theoretical section in feet and decimals. The right-hand one is the same thing adapted to measurements in feet and inches for brickwork. Of the equations in each case, the upper one is $\frac{h^2}{5}$ for the area including the small triangle. The lower one is the area without it. The lowest number denotes the area of the figure in square feet.

Discussion by C. D. Norton.

A few years ago the writer was given the above empirical formula for the design of brick retaining walls, the principles of which are just as applicable to those

built of concrete or stone. The author, Mr. Symonds, was chief engineer of the Government Railways in Portugal. Later he had charge of the construction of a large

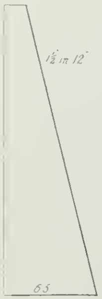


Fig. 6.

Fig. 7.

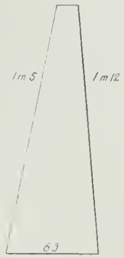


Fig. 8.

part of the South Eastern Railway in England, and was employed on the first tunnel to be built to a predetermined line. These walls were used principally in earth cuttings to avoid the purchase of valuable land, and were not called upon to carry a live load as is the case of an abutment for a bridge. Figs. 6 to 11 show a comparison of various standard types of retaining walls. Those designed by the above formula are the lightest, but it must be taken into consideration that the workmanship was of the best, and in the days that these were built speed was not the important factor that it is to-day.

One thing to which the writer takes exception is the remark about placing the material behind the wall, as given suitable conditions and a fair amount of carelessness, it is possible to wreck any wall except one designed to withstand hydrostatic pressure.

In a retaining wall the cheapest design is that which takes into consideration the placing of the backing in addition to the cost of the masonry. A minimum can only be attained by a due consideration of the material to be placed, and the labor and methods employed. It will be found in nine cases out of ten, that wrong dumping of material is due to mere laziness, either mental on the part of the employer or bodily on the part of the laborer; and it is the duty of the engineer to note these things and, if possible, to remedy them.

It will be noticed that Mr. Symonds does not take frost into account, possibly because in the south of England the mercury seldom falls below 0° F., and then only for a short period; so that the depth to get a good foundation is plenty deep enough to ensure against heaving.

In a small village near Toronto, the authorities received the sum of $500 to build a small retaining wall, which sum was hardly sufficient for one of standard design; so the wall was considerably lightened, and the foundation was sunk only 18 inches below ground level. After the wall was finished it was left for two months to cure, and then the backing was tamped in most carefully. A cross-section is shown in Fig. 11. When finished the amount of pressure against the back of the wall was almost negligible. The front of the wall was banked up to about 4 feet above ground level. The cost of this extra tamping and filling, about $10, was paid out of the road building fund.

The above procedure would not have been practicable but for two things: the contractor on the job did not profess to be an authority on retaining walls, and the writer was able to be on the work all the time, and to see that his orders were carried out.

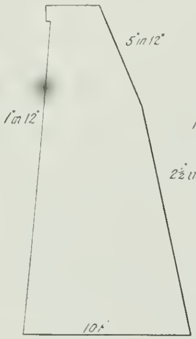


Fig. 9.

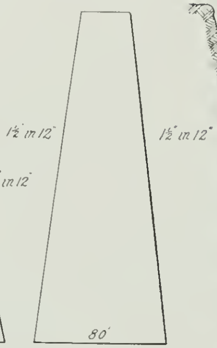


Fig. 10.

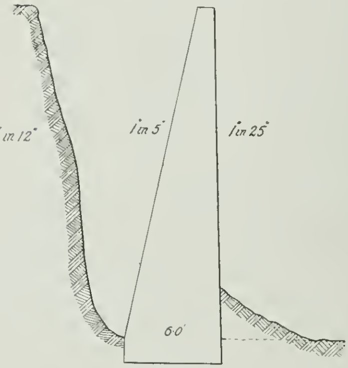


Fig. 11.

Figs. 6 to 11 show various walls; the three railway walls are designed to take care of the heavy superimposed load due to fast-moving traffic, although Trautwine considers his capable of taking care of these loads also.

VANADIUM STEEL IN LOCOMOTIVES.

The extent to which vanadium steel is entering into the manufacture of locomotives is indicated by the following table, showing the vanadium parts applied to locomotives built or ordered in the United States from Jan., 1913, to May 15th, 1914:—

Name of part.	No. of engines equipped.	No. of parts applied.
Driving axles	476	1,297
Main rods	377	822
Side rods	284	1,986
Frames	993	2,054
Crank pins	198	612
Piston rods	69	138
Springs (engine and tender)	366	....
Engine truck axles	62	62
Wheels	...	700
Tyres	...	1,150
Cylinders (vanadium cast-iron)	260	540

With the exception of wheels and tires this applies to new power only.

SYSTEM IN ROAD MANAGEMENT.*

By Charles J. Bennett,
Highway Commissioner of Connecticut.

In consideration of a topic of this character, it must be realized that there are certain principles to be applied in organizing or systematizing a highway department, which can be applied generally to the problem wherever a department of this character is to be formed. Further than that we cannot go. The particular methods of accounting, the minutiæ, the forms, types of books, methods of reporting and recording reports are in every instance a peculiar problem to be solved locally and in the manner best fitted to give a solution of the peculiar difficulties which arise on account of position and magnitude of the department geographically or financially.

Having in mind, therefore, that the detailed phases of the problem are local, there will be no endeavor in this paper to outline an ideal system of accounting, reports and records for a highway department, for such a system would apply probably only to that particular department with which the writer is more nearly familiar. There will be, however, an attempt made to show in a general way, what, in the estimation of the writer, are the broad principles which can be applied to systematic management of a highway department, whether it be town, city or state.

In the first place, it is necessary to realize that there are two results to be secured:

(1) The proper and economical spending of a certain amount of money in the way best fitted to serve the general public, and

(2) The presentation of the method of spending this money to the public, so that it may be thoroughly informed as to how its money has been apportioned and what results have been reached. Such a record or report made to the public should be in simple language so that the most uninformed may understand the results desired and the ends achieved.

In connection with the first proposition, *i.e.*, the spending of money to get the best results. The first requisite in organizing a system of this kind is the record or system of bookkeeping which should show at all times the condition of the accounts and keep a check on the expenditures made for specific purposes. Such a system should be simple and familiar to all the employees of the department and should show graphically, at a glance, the amount of the appropriations made for specific purposes and a summary of the definite projects on which this money should be expended with the total weekly or monthly expenditures for the purposes defined. This information should be available to all the employees and should be so plain as to make it possible for a change in the personnel of the office force without a consequent confusion arising from a complicated and abstruse system of accounts.

In connection with this system of bookkeeping and system of reports of work necessary, the orders for the work to be done should be immediately compiled and entered in the books so that the disbursements may be kept up to date. There should be no possibility of verbal orders which would call for expenditures of money without an accompanying written report and order, which should be entered at once in the ledger. This system of accounts should provide also for a periodic statement of the financial condition of the department, which statement or balance should show not only the cash available, but also the actual amount available after all the liabilities, bills and debts of the department were paid.

Having formulated such a system of accounting, a force of employees should be organized in such a manner that the system of accounts may be followed and in such a way also that the general idea of spending the money economically and well be firmly established.

The first idea which should be applied in the organization of a highway department is the military system; that is, the department should be subdivided so that each part might have certain duties with a definite amount of money to spend. Each subdivision should report directly to the superior officer and through this superior officer to the military head. The organization should be such that no orders should be passed around a subordinate, but should rather go through a subordinate. It is quite necessary in dealing with a force of any magnitude that the rank and file should know the purpose of the organization and the wishes of the chief. In other words, the department should be imbued with the spirit and aims of the man at the head, for in this way each man will work, so far as is possible, along the same lines and the results gained will be more nearly uniform and standard.

An effort should be made to build up patriotism in the department, which should work for the betterment of the road system rather than for the personal benefit of the employees or of the political party which is responsible for the appointment of members of the department. A modified civil service system is a good thing, in that it makes the men more sure of their positions than under a political system. Such a civil service should, however, provide for the removal of employees by the head of the department without applying to any outside body, such as a State or Municipal Civil Service Commission. The whole idea of such a department and the organization of the force, should be to secure the right men for the right places and keep them there while they give good service. There is nothing which can disorganize a department so much as the right of an employee to apply to some outside body which has no knowledge of conditions and which can only judge of a man's ability or his right to hold a position, by an examination on his technical knowledge or by a brief hearing. The measure of a man's value is in the results he gains in actual service and knowledge of a man's ability can only be secured by the record of his achievements from day to day.

In the organization of a force, a chart should be prepared showing the connection between employees, showing to whom an employee should report and stating distinctly what his duties shall be. The best results are to be gained by delegating authority to a man and placing confidence in him, having in mind the theory that men are by nature honest and will endeavor to do right and gain good results if given the opportunity. Allowance should be made for honest mistakes and a careful record kept of such mistakes so that a man may realize, when removed, that the reasons for his removal are sound and based on results showing his lack of ability.

In selecting employees to deal with the public, men should be sought who are tactful, intelligent and polite in their intercourse with people. The employee should be instructed that at all times it is necessary for him to be fair and reasonable and to keep his temper. A public employee is a servant of the public and in his dealings with citizens, should realize this fact, but he should also be firm and not afraid to refuse an unreasonable request.

Given, then, a system of accounting in the organization, the members of this organization must bear in mind that if they are kept informed as to the purpose of the

*From paper read before the 4th American Road Congress, November 9 to 14, 1914.

department in which they work, they should on their part, keep their superiors well informed of their own movements, the amount of work done and the character and cost thereof. In other words, a method of reporting work should be established and kept which should give plainly and simply, all the necessary information as to the actual physical operations carried on by the employees. The local situation will govern the extent and frequency of such reports but they should show primarily and in a clear way, the work which the employee is trying to do, the probable cost of the work to be done before it is started, and from time to time the actual cost, including remarks as to the success or failure of any particular experiment. There should not be an endeavor to make complicated reports which should show minutiæ to the point of the ludicrous, for a system of reporting which becomes so complicated that it is not simple of understanding, fails utterly in its purpose.

The recording of reports in connection with the accounting system should be made in such a manner that through these records the outsider, either layman or professional, may secure information as to the comparative cost of certain classes of work, the success or failure of certain types of roads and the financial value of expenditures for certain specific purposes. For instance, it might be possible to demonstrate in a certain instance, by a system of records that a larger first cost of construction would be very much more economical eventually than a small first cost with a corresponding large charge for maintenance in future years. The system of records should, therefore, show the ultimate result from an expenditure, which ultimate result should be gained from records made over a long term.

The above discussion has covered mainly the first principle which was stated, namely, the endeavor to get good work with the money appropriated.

A road department has, however, the duty of presenting its operations to the public eye, not only as results on the roads themselves, but in the success or failure of the department as a financial proposition. This presentation must be made in the form of a periodical report to some superior body, as the mayor of a city or the legislature of a State. The writer finds, in perusing many of the reports made, that there is an entire lack of system in presenting the information, and no effort made to make the report clear. Most reports are made in such a manner that an expert accountant would be needed to find out results gained and even then, these results would be of little value. The spirit shown most in reports is that they claim general excellence for the department and try to justify its continuance. Certainly there are some failures made by roadbuilders which should be reported for the good of the work. Reasons for failure should be stated, whether the failures be financial or physical.

It is quite possible and necessary to make an annual report which is readable and interesting to the layman. The text portion of such a report should be written in plain English without technical terms and with general results stated broadly and succinctly. Tabulation of records should be made as simple as possible and the cost per unit should give not only definite figures, but should state, furthermore, just what details were included in the units of work done. For instance, in one locality maintenance of roads does not include the oiling of the surface, while in other reports this oiling is included which, of course, makes it impossible to compare the two costs, and for this reason, and many others, as stated above, the reports should show definitely what details are included under each heading, and the cost might be analyzed accordingly.

The writer wishes to make clear again that there is no question in his mind that the system should be simple and operative rather than complicated and unwieldly. The simpler the method of bookkeeping, organization, reporting and recording, the more successful will be the results in spending the money economically and well and the more successful will be the opportunity of the official at the head to present his information so that it will be of benefit first, to the general public, and, second, to the profession of which he is a member.

CROSS-SECTIONING.

By J. A. Macdonald.

ONE of the most important problems that confronts the surveyor is the setting of "slope stakes," called cross-sectioning, from which may be determined the amount of earthwork in cut or fill, and which mark the extreme limits of the operations of the construction corps in building railways, highways, sewers, canals, irrigation ditches, etc.

The problem is as follows: Given the required width of finished roadbed or channel, with proper side slopes (depending upon the kind of material) it is required to determine where these side slopes will intersect the natural surface of the ground with reference to the centre line of the survey. The centre line is defined by stake, carefully aligned and levelled, and a profile of it is prepared upon which the grade line is laid down, showing the elevation of the finished roadbed or channel with reference to the natural surface of the ground.

Let us assume the ground to be level transverse to the centre line. Depth of cut at centre, 12 feet; side slopes, 1½ feet horizontal to 1 foot vertical; width of cut at bottom, 20 feet. (See Fig. 1.)

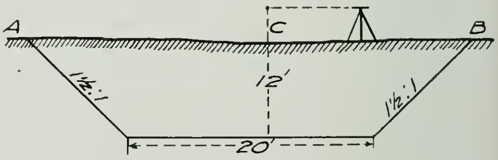


Fig. 1.

Set up the instrument in some convenient position that will command a view of as much ground as possible. Hold the rod at the centre stake and note the reading. Suppose it to be 3.5 feet. If the ground is level, the distance from C to B is evidently 10 + (12 × 1½), or 28 feet, and the rod should again read 3.5 feet when held at B. The point A would be similarly found.

The notes would be kept as shown below:

Sta.	Dis.	Left.	Centre.	Right.	Area.	Cu. Yds.
100	50	$\frac{+12.0}{28}$	+12.0	$\frac{+12.0}{28}$		
101		$\frac{+3.0}{14.5}$	+6.0	$\frac{+7}{9}\ \frac{+9.2}{23.80}$		
101	50	$\frac{+2.5}{13.75}$	+5.0	$\frac{+8.0}{22}$		

This example illustrates one of the simplest cases that occur in practice. Let us now take the case of a line located upon the side of a hill, as in Fig. 2.

Depth to grade at centre, 6 feet; width at bottom, 20 feet; side slopes, $1\frac{1}{2}$ to 1. As before, hold the rod upon the ground at C and determine the height of instrument above C. Suppose this to be 5.5 feet. If the ground were level through C it would be necessary to measure to the right $10 + (6 \times 1\frac{1}{2}) = 19$ feet to the point D, and the rod should read 5.5 feet. Instead it reads, say 2.8 feet. We know, therefore, that we have not gone out far enough by $(5.5 - 2.8)\ 1\frac{1}{2} = 4.05$ feet, if the ground were level through the point D, bringing us to the point E where the rod should read 2.8 feet. Suppose it reads 2.3 feet. We must then go out 0.75 foot farther, each move bringing us closer and closer to the point B. This operation may be repeated as often as is considered necessary, but with a little experience in this sort of work the instrument man can direct the rod closely enough to the point B for all practical purposes. We then enter the notes in the second line of the record shown above.

Upon the left of the centre, these operations are reversed. That is to say, we measure out 19 feet and instead of the rod reading 5.5 feet, it reads, say, 8.5 feet. We know then that we are out too far by 4.5 feet. We then move in toward the centre the required distance and read the rod again, noting how much it differs from 8.5 feet, if any, and enter the final results in the notes.

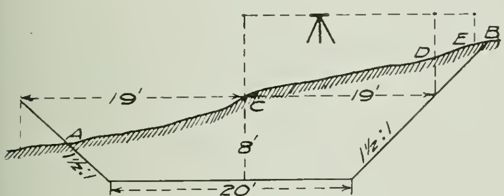


Fig. 2.

A third case is shown in Fig. 3, in which the transverse slope is not uniform. The method of procedure is the same as in the other cases, but the rod should be held at the point where the slope changes in order to find its height above grade. Enter this and the distance out in the third line of the notes.

The transverse section may be very irregular, in which case it may be necessary to take readings at several points in order to calculate the area of the sections with more exactness. At times a section will be cut partly in rock and partly in earth, forming a compound section. Each material will, of course, have its own proper side slope, and the depth and extent of each must be determined by soundings.

In case the section is in fill instead of in cut, the method is the same as in the preceding cases, as will be illustrated in the following examples.

Let us first take a section level transversely. (See Fig. 4.) In this case the finished grade is to be 9 feet above the point C. Hold the rod at C and suppose it reads 3.25 feet. Since the ground is level, we go out to the right and left $9 + (19 \times 1\frac{1}{2}) = 22.5$ feet, and set the stakes at A and B, entering the record in the notebook as before, except that the numerator of the fraction will be marked — instead of +.

We will next take the case where the surface of the ground has a transverse slope, as in Fig. 5. Hold the rod at the point C, and suppose it reads 9.25 feet. If the ground were level through C we would have to go out to the right $9 + (6.25 \times 1.5) = 18.4$ feet to some point D. But there the rod reads, say, 1.5 feet, hence we know we are out too far by $7.75 \times 1.5 = 11.63$ feet, bringing us back to some point as E, and the rod now reads, say, 3.5 feet, so we move out again $2.0 \times 1.5 = 3$ feet. We

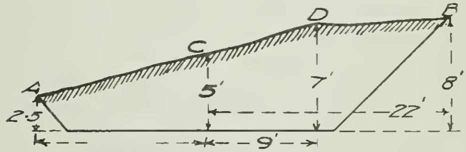


Fig. 3.

move back and forth until we find the point B, where the computed rod reading and the actual reading agree.

Sometimes it will be found that a part of the section is in cut and a part in fill (Fig. 6), but methods outlined will serve in any case.

Cross-sectioning Irregular Sections.—The prismoids have straight lines joining corresponding points in the two cross-sections. The centre line must be straight between two cross-sections. If a ridge or valley is found lying diagonally across the roadbed, a cross-section must be interpolated at the lowest (or highest) point of the profile. Therefore a "break" at any section cannot be said to run out at the other section on the opposite side of the centre. It must run out on the same side of the centre or possibly at the centre. Very frequently complicated cross-sectioning may be avoided by computing the volume, by some special method, of a mound or hollow when the ground is comparatively regular except for the irregularity referred to.

When the natural slope cuts the roadbed there is a necessity for both cut and fill at the same cross-section. When this occurs the cross-sections of both cut and fill are often so nearly triangular that they may be considered as such without great error, and the volumes may be computed separately as triangular prismoids without adopting the more elaborate form of computation so necessary for complicated irregular sections. When the ground is too irregular for this the best plan is to follow

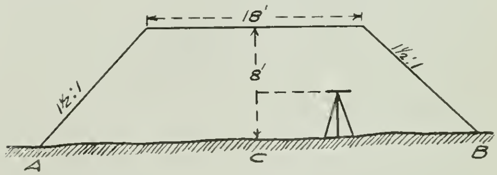


Fig. 4.

the uniform system. In computing the cut, as in Fig. 6, the left side would be as usual; there would be a small centre cut and an ordinate of zero at a short distance to the right of the centre. The area for fill may also be computed by a strict application of the rule.

Compound Sections.—When the cut consists partly of earth and partly of rock, as in Fig. 7, a compound cross-section must be made. If borings have been made so that the contour of the rock surface is accurately known, then the true cross-section may be determined. The rock and earth should be calculated separately, and this will require an accurate knowledge of where the rock

"runs out"—a difficult matter when it must be determined by boring. During construction the centre part of the earth cut would be taken out first and the cut widened until a sufficient width of rock surface had been exposed so that the rock cut would have its proper width and side slopes. Then the earth slopes could be cut down at the proper angle. A "berm" of about three feet is usually left on the edges of the rock cut as a margin of safety against a possible sliding of the earth slopes. After the work is done, the amount of excavation that has been made is readily computable, but accurate preliminary esti-

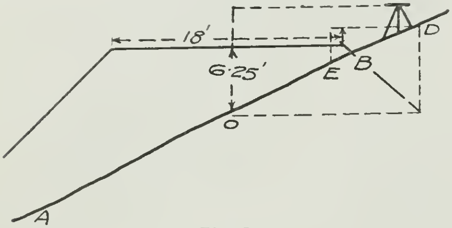


Fig. 5.

mates are difficult. The area of the cross-section of earth in the figure must be determined by a method similar to that developed for borrow-pits.

The distance between the sections longitudinally will depend upon the nature of the ground. On uniformly sloping or level ground they may be taken 100 feet apart. Over uneven ground it may be necessary to take them as closely together as 25 feet, or even less. In the sections themselves, a sufficient number of rod readings should be taken that the area of the sections may be determined with reasonable accuracy.

After the field work is completed, the notes are plotted, usually upon cross-section paper, and the areas determined either with a planimeter, by Simpson's rule, or some other method. These sections then divide the earthwork into a system of prismoids of which the volume

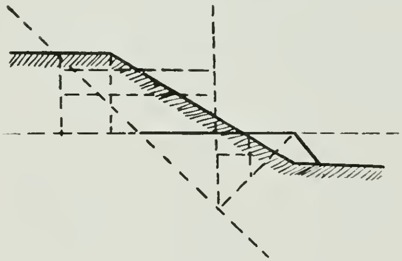


Fig. 6.

must be calculated. The formula for calculating volumes is known as the Prismoidal Formula, and is as follows:

$$\frac{l}{6 \times 27}(A + 4M + B);$$

in which l is the length between consecutive sections; A, one end section; B, the other end section, and M the section midway between the two. The result is given in cubic yards.

The mistake must not be made of assuming that M is a mean between A and B, but a theoretical section must be plotted whose dimensions are a mean between those of A and B. This often results in quite a complicated problem, and various other formulas have been devised to give sufficiently close results without the labor and time involved in the preceding.

It should be realized at the outset that the accuracy of the result of computations of the volume of any given mass of earthwork has but little relation to the accuracy of the mere numerical work. The process of obtaining the volume consists of two distinct parts. In the first place it is assumed that the volume of the earthwork may be represented by a more or less complicated geometrical form, and then, secondly, the volume of such a geometrical form is computed. A desire for simplicity (or a frank willingness to accept approximate results) will often cause the cross-section men to assume that the volume may be represented by a very simple geometrical form which is really only a very rough approximation to the true volume. In such a case, it is only a waste of time to compute the volume with minute numerical accuracy. One of the first lessons to be learned is that economy of time and effort requires that the accuracy of the numerical work should be kept proportional to the accuracy of the cross-sectioning work, and also that the accuracy of both should be proportional to the use to be made of the results.

Prismoids.—To compute the volume of earthwork, it is necessary to assume that it has some geometric form whose volume is readily determinable. The general method is to consider the volume as consisting of a series

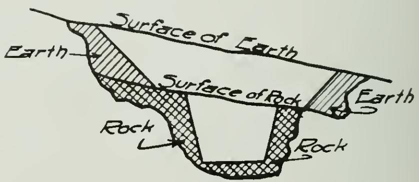


Fig. 7.

of prismoids, which are solids having parallel plane ends and bounded by surfaces which may be formed by lines moving continuously along the edges of the bases. These surfaces may also be considered as the surfaces generated by lines moving along the edges joining the corresponding points of the bases, these edges being the directrices, and the lines being always parallel to either base, which is a plane director. The surfaces thus developed may or may not be planes. The volume of such a prismoid is readily determinable, while its definition is so very general that it may be applied to very rough ground. The "two plane ends" are sections perpendicular to the axis of the road. The roadbed and side slopes (also plane) form three of the side surfaces. The only approximation lies in the degree of accuracy with which the plane (or warped) surfaces coincide with the actual surface of the ground between these two sections. This accuracy will depend (*a*) on the number of points which are taken in each cross-section and the accuracy with which the lines joining these points coincide with the actual cross-section; (*b*) on the skill shown in selecting places for the cross-sections so that the warped surfaces shall coincide as nearly as possible with the surface of the ground. In fairly smooth country, cross-sections every 100 feet, placed at the even stations, are sufficiently accurate, and such a method simplifies the computations greatly; but in rough country cross-sections must be interpolated as the surface demands. Carelessness or lack of judgment in cross-sectioning will introduce errors of such magnitude that all refinements in the computations are utterly wasted.

The process of cross-sectioning consists in determining at any place the intersection by a vertical plane of the prism of earth lying between the roadbed, the side slopes, and the natural surface. The intersection with the roadbed and side slopes gives three straight lines. The intersection with the natural surface is in general an irregular line. On smooth regular ground or when approximate results are acceptable this line is assumed to be straight. According to the irregularity of the ground and the accuracy desired more and more "intermediate points" are taken.

"Setting Up" the Instrument.—In setting up the level to secure horizontal sights, plant the legs firmly in the ground at approximately equal distances apart, so as to make the levelling plate horizontal. The level is, with few exceptions, never placed in line (except when being adjusted under the peg method). It is usually placed in some convenient spot where the greatest number of horizontal sights can be secured. As already stated, the tripod legs must be so placed as to make the plates horizontal. This will save time in bringing the bubble in its proper position. Should it be required to set up the instrument on the side of a hill, place one leg at an altitude and the other two in apparent line with each other, but where the tripod is adjustable the proper method is apparent.

After the instrument is set up and levelled, focus the eye-piece upon the wires and focus the object-glass on the rod by means of the screw placed for that purpose on the top or side of the telescope. Care should be taken not to take a reading until the bubble has been carefully observed and brought in the exact centre of the bubble tube. When this is completed, sight through the telescope and note the rod reading or set the target rod; again look at the bubble and see if it has moved away from its former position; if not, again sight on the rod and see if the first observation was correct. Should the intersection of the cross-hairs fail to coincide with the horizontal and vertical lines of the target or the centre of the rod, the rodman is to incline the rod by the signals of the observer, until it coincides or is in line of collimation.

PURIFYING PAPER AND PULP MILL WASTE WATER.

A means of dealing with any waste waters that offer considerable difficulties in their treatment, especially those coming from paper pulp factories, depends on the use of a mixture of hydrated silica and salts of iron and alumina prepared from ordinary clay by igniting it in a vacuum and treating the residue with such small quantities of sulphuric acid and water that the silica is obtained in a soluble form. The iron always present in common clay greatly assists the clarifying action of the soluble silica on the waste lyes, as does the sulphate of alumina also formed.

The novelty of the invention consists in the ignition of the clay (to destroy its organic matter) in a vacuum, otherwise it is difficult to get the silica in a soluble form, and the soluble silica is the main effective agent, the iron sulphate and aluminum sulphate being of secondary although considerable importance.

The details of the manufacture are as follows:—1,000 lbs. of the ignited clay is treated with a mixture of 400 lbs. of concentrated sulphuric acid and 1,500 lbs. of water in the cold with constant stirring for about one hour. It is claimed that the product will clear one thousand times its weight of waste pulp water sufficiently in from ten to fifteen minutes to permit of its discharge into a river. The sediment is collected and re-ignited for use again.

ENGINEERING SUPERVISION OF ROAD CONSTRUCTION.*

By W. S. Keller,
State Highway Engineer of Alabama.

THIS question confronts every commission that has the building of good roads, and it would appear to the business man that the wisdom of having an engineer supervise the expenditure of large sums of money on highway construction, would not be questioned any more than a railroad company would question the wisdom of employing an engineer to locate and supervise the construction of a railroad.

We may, therefore, for discussion, divide this subject under two general heads:

Is engineering supervision of road construction necessary?

Why is an engineer better fitted to supervise road construction than a practical road builder who is not an engineer?

Engineering supervision of road construction is absolutely necessary and this statement is proven every day, positively and negatively. A layman riding over the roads can tell at a glance a road that has been located and built under the direction of an engineer. When he rides over a road that has been constructed along the old trail, located by the Indians and early settlers, without any regard whatever for grades and very little for drainage, he sees the hand marks of the commissioner, who saves his country the salary of an engineer, and spends it thrice over in useless work and expensive maintenance.

Despite the fact that a majority of commissioners or supervisors have had no training whatever in road building, they will concede to no one that they are not as well qualified to direct road work as any engineer they can employ. They will often admit that an engineer should locate and stake off a road, but they think his duty ends there. It is just as necessary that an engineer supervise construction work as it is that he should locate the road. How many commissioners can tell how much it costs to move a yard of earth or how much it costs to install pipe of various makes—how much per cubic yard their concrete culverts are costing them? You may say we know how much per mile our roads are costing, why should we bother to know the unit cost? Why does a merchant keep the unit cost of his wares? Because he desires to buy from the man who sells the cheapest. So, a county should know if its roads are costing more than they should.

The commissioners of a certain county in Alabama claimed that they were building roads as cheap or cheaper than any contractor could do the work. They had an engineer estimate the cubic yardage of earth moved for a certain period of time and to their surprise it was costing 37½ cents per cubic yard when the average contract price in Alabama for three years had been 23 cents per cubic yard. Authorities should know whether they are getting value received for their money, and an official who overlooks such a vital question, is not true to the trust placed in him by the people.

Many counties are imposed on in the purchase of material and supplies and are actually paying more for such in large quantities than individuals have to pay for the same in small amounts. This is usually attributed to

*Extracts from paper read at the Fourth American Road Congress, Atlanta, Ga., Nov. 9-14, 1914.

either carelessness, politics, or a false idea some of the commissioners have as to their duty. I believe the duty of commissioners, in so far as road building is concerned (and it can equally as well be applied to other public matters) is to purchase with as much care and secure just as low prices as they would if buying for themselves as individuals, regardless of whether the goods purchased come from local or foreign merchants; of course, giving always the preference to local merchants, if their wares are as good and prices as low as those of outsiders. It is not the duty of road authorities to conduct county affairs so as to make money for individuals or to give jobs to political henchmen. If a competent man cannot be found within the borders of a county fit by experience for a position such as foreman, it is right and proper that a competent man should be secured from elsewhere.

The remedy for these ills is, unquestionably, to have some one in charge of road building qualified by education and training and free from political influences, who can be held responsible for results. Very few counties have commissioners or supervisors who devote all of their time and attention to their office, and it is self-evident that an engineer trained in road building will get better results than can any set of men who give only a few days in the year to their public office.

As to the second division of this subject, "Why an engineer is better fitted to supervise the construction of roads than a practical road builder who is not an engineer." First, an engineer is indispensable, even though you have a splendid layman to supervise the work. A large percentage of all roads to be constructed require relocation, profiles made, grades established and if the work is to be contracted, the road must be cross-sectioned and the yardage of excavation and embankment calculated and made to balance as near as possible. Such work a layman cannot do. Who is better fitted to supervise the construction of any job than the man who plans and specifies the work? The road supervisor is usually uneducated and it is practically impossible for him to correctly account for the expenditure of large sums of money and equally as impossible for him to keep cost account of his work.

This condition is usually brought about by a disposition on the part of the board of supervisors or commissioners to economize. Unfortunately, many county commissioners can see only the engineer's salary to be paid twelve times a year and the inevitable result that there will be quite a decrease in the number of days they can legitimately demand pay for laying off and superintending the building or repair of roads in their respective districts. In other words, the engineer is a usurper, taking away the salary of those guardians of the people's right who are so anxious to save money for the people that they save $200 per month engineer's salary and spend $500 per month in doing it. So long as we elect officials because of their popularity rather than fitness, and pay them a mere pittance for their services, we may expect many of them to be incompetent and often dishonest. A foreman in the employ of a certain county was discharged by the commissioner of the district in which he had been working. The commissioner gave as a reason for discharge, that he himself could look after the teams and hands and thereby save the county several dollars a month. The foreman resented his being discharged and took upon himself the investigation of the commissioner's record. He found that on a certain day this commissioner drove seven miles to a small bridge where he then and there made a contract with a party to repair the bridge at a cost of $1.50. A few days later he went back to this bridge to inspect the work he had ordered done. The record of the Commissioners' Court showed that cost of repairing was $1.50 and cost of inspection two days at $3 to $6. He certainly was entitled to pay for at least the time consumed by himself yet it is manifestly wrong for such a condition to exist that cost of supervision is four times that of construction or repair. This would have been a very small matter to an engineer who, while having the bridge repaired, would attend to many other duties.

It is almost impossible to convince many county officials that an engineer can easily save his salary several times over by making certain changes in location and grade and by economically administering the affairs of the county. As a general rule a county gets more in return for money spent for engineering services than for any other single item connected with road construction. A good engineer is a dividend producer for a county. In speaking along this line at the American Road Congress held in Atlantic City in 1912, Col. W. D. Sohier said:

"You will find if you look at any private corporation, that the ordinary engineering expenses for any work of the character of road building, any constructional work, is usually about 10 per cent., and that it is good money well spent."

A highway engineer should have a good technical education and to be successful, he must be practical and he must be a diplomat. He should be sober, honest, energetic and think more about the work he is trying to do than the pay check he will receive at the end of the month. When taking charge of a county's road affairs he should convince the commissioners that he knows more than they do about building roads and then proceed to prove it by doing good work. Unless an engineer can absolutely convince his Board of Commissioners that he knows his business, he had best resign. Trouble is often brought about by the engineer failing to have a thorough understanding as to his duties. This can easily be avoided if, when an engineer makes a contract with a county, he clearly sets forth in this contract what his duties are. If he is to be held responsible, and he should be, for the success of the undertaking, he should have full power to employ and discharge those under him. I think this is well expressed in Rule 2 of Rules and Regulations of the State Highway Department of Alabama, which reads as follows:

The functions of the Commission are judicial and those of the engineer, executive. The engineer will receive and carry out the directions of the Commission and shall, in turn, direct those under him. The engineer shall have full charge of construction work, directing it in all its details. Any orders the Commission wish to give an employee shall be given through the engineer, and the engineer shall have the right to employ, with the consent of the Commission, and to suspend, subject to discharge, without consulting the Commission. All suspensions shall be reported to the Commission for such action as they deem necessary.

The spandrel or face walls of a concrete arch may be carried up at the same time as the arch ring is laid, or may be connected with it later by leaving short lengths of steel projecting radially from the concrete of the arch. Some engineers require that arch centering shall be lowered sufficiently to allow the arch ring to assume its permanent set before parapet walls are placed.

The largest power transmission by means of chains, according to F. L. Morse, is one consisting of two drives, each of 2,500 h.p. capacity, for operating a 5,000 h.p. gnerator in an Idaho power plant. There are eight chains all told, 21 in. wide, and of 2 in. pitch. The sprockets have 71 and 47 teeth, and are of 45.59 in. and 30.31 in. in diameter, respectively, and each of a face of 92 in. The sprockets are 120 in., centre to centre, and each carries, as stated, four chains, each 21 in. wide.

ICE TROUBLES IN HYDRO-ELECTRIC PLANTS.

In Canada the designer of a water power development has before him the task of providing a means of eliminating or minimizing the effect of ice upon plant operation and power production. It is an important problem even though there be no direct liability of injury to the plant equipment. Apart from trouble due to ice blocking the water entrances, the presence of it in the river may have such a marked effect upon the power production that it should never be overlooked in the study of a development where ice conditions in winter are liable to obtain.

A good analysis of ice formation, its effect upon the operation of a plant, and suggested methods of overcoming the difficulty, are presented by Mr. M. C. Hendry, chief engineer for the Water Power Branch, Department of the Interior, in his report on Bow River power and storage investigations. His treatment of the subject is given as follows:—

There are three kinds of ice which, owing to their effect upon the operation of water-power plants, are of interest to the engineer. These are: Board or sheet ice, frazil ice and anchor ice.

Sheet Ice.—Sheet ice is that kind of ice which is formed upon the surface of lakes, smooth-flowing rivers, ponds, etc. The process of formation is an interesting one, and begins with the arrival of cold weather. As the season advances, the water on the surface gives up its heat by surface radiation, convection currents are set up, the cold surface water falls and the warmer water below rises; this in turn gives up its heat; by a continuation of this process, the temperature of the whole body of water is gradually lowered until it reaches 39° F.; at that temperature convection ceases, and the water on the surface is cooled down until freezing point, 32° F., is reached. The first indication of the formation of ice is the presence of long needle-shaped crystals on the surface. These rapidly increase in number and size until finally the whole surface is covered. This surface layer becomes more compact, and the ice increases in thickness, as the underlying water gives up its heat by conduction through the ice. The rate of growth diminishes, however, as the thickness of the sheet increases.

When the ice sheet is once formed, radiation to a very great extent ceases. This is due to the fact that the ice is seldom clear, and is generally snow-covered and the heat rays are unable to penetrate under such conditions. If the ice was clear and solid, the heat rays could then penetrate, and the loss of heat from the water below would go on at a much more rapid rate, and consequently the growth of ice would be more rapid.

The pressure of any sheet ice in a river immediately above a power plant has a beneficial effect upon its operation rather than the reverse. The reason for this will be understood after the subject of frazil and anchor ice has been dealt with.

Frazil Ice.—Frazil ice, known also as "slush ice," is perhaps the ice formation which has the most serious effects upon water-power operations. It is always formed in the open channels where the current is too swift or turbulent to allow the formation of sheet ice, and its formation is dependent upon disturbance or agitation, consequently swift turbulent streams are very prolific in its production; it occurs in needles, the fineness of which are due to the amount of agitation. In such places as rapids, and at the foot of falls, these needles are very fine, but they increase in size and thickness where the flow is less rapid and disturbed. Frazil ice is always surface-formed, but the ice crystals rapidly become distributed throughout the whole body of water. This gives rise to the saying that the water is "thick." This condition occurs only during a period of extreme cold, combined with great surface agitation, due to rapids in the river, or wind. The direction of the wind relative to the flow of the river has a varying effect on production of frazil, a wind blowing upstream produces more frazil than one blowing downstream, on account of increased surface agitation.

The conditions that make for the greatest production of frazil ice are a dull, stormy day, with wind upstream. A great amount of frazil may be produced upon a clear, cold night with wind, but on a clear, cold day with wind there is not so great a quantity formed, due to the absorption of heat from the sun's rays at the water surface. Professor H. T. Barnes, in his book on "Ice Formation," says that "a stretch of open water makes a very much greater quantity of ice in the form of frazil crystals than could be produced as a surface sheet, if the water were sufficiently quiet to allow such to grow." It is this production of frazil which gives rise to so much trouble, the steam becoming blocked with the mass. Where an ice sheet exists, conditions are often aggravated, the frazil blocking the waterway underneath, at times causing complete stoppage of flow.

Anchor Ice.—Anchor ice, "ground ice," the German name "Grundeis" and the French-Canadian term "moutonne" are among the many names given to this particular form of ice. As this list of names would indicate, it has attracted very widespread attention, and a number of scientists have published papers in which its formation has been discussed. The name "anchor ice" perhaps best describes it, and is the one by which it is most widely known in this country.

The peculiar feature which gives it this name is the fact that it is formed upon the bottom of the rivers or streams. Many theories as to the reason of the formation of ice upon the bottom have been advanced. That as set forth in a paper by Dr. Farquharson, which he published in 1835 and 1841 is generally accepted as the correct one. He attributes the formation of anchor ice to the radiation of heat from the surface of the stream's bed.

It is remarked that this cooling by radiation, and consequent formation of anchor ice, occurs only in streams whose beds are composed of gravel, stones and boulders, but not in clay or mud-bottomed streams; also that the formation of the ice is greatest on the rocks and stones of dark color.

The formation of anchor ice is most rapid during a clear, cold night (conditions which are favorable to rapid radiation). On a clear, cold day, the sun's rays affect the formation; in fact, it is universally noted that on the appearance of the sun in the morning, the ice becomes loosened from the bottom and rises to the surface. Its appearance when floating has given rise to the French-Canadian term, "moutonne," on account of its resemblance to the backs of white sheep.

It has been noted in connection with anchor ice, that its formation does not occur under cover. A bridge spanning a stream retards radiation and prevents its formation, and it is seldom found where the stream is covered with an ice sheet.

The names frazil and anchor ice are often confused and are frequently used as being interchangeable; the term "anchor ice" being used to designate ice found attached to the bottom, regardless of the method of formation.

Professor Barnes says that "in a shallow, smooth-flowing river, we are more likely to have anchor ice formed in excess, whereas in a deep and turbulent stream we are likely to have more frazil. It is hardly likely, how-

ever, that there will be a great difference in the amount of frazil formed in either case; it will probably be that more or less anchor ice will appear in proportion."

The Montreal Flood Commisson in their report deal exhaustively with the question of ice formation. The following is an extract from that report:—

"The terms 'anchor ice' and 'frazil ice' are indifferently applied to the same material, but the first evidently is most applicable to this ice when found in the bottom of the river. In one respect the two are identical; that is, both are exclusively the production of open water. There is no formation of either when or where the surface is covered with ice, and whereas large formations of both take place in the beginning of winter over the vast surface below Lachine Rapids, the further formation of this ice ceases as soon, and whenever the ice-bridge is formed. Frazil, as distinguished from anchor ice, is formed over the whole unfrozen surface above and below Lachine Rapids, between Prescott and the tide-water and wherever there is a surface current or wind agitation to prevent the formation of bordage ice, while anchor or anchored ice, except in the shallowest portions of the current, does not appear in the deeper water until zero weather sets in."

In this report the formation of anchor ice is not ascribed to radiation from the river bottom, but rather to the cooling of its surface through the contact with the frazil-charged water. Proceeding with the description on anchor ice, the report says:—

"On the approach of mild weather, it becomes detached from the bottom, sometimes bringing up with it gravel and stones, and may be seen as a dark-colored mass bursting up all over the surface with considerable force, and with a hissing sound, which rises a foot or more above the surface, but falling back, shows only a few inches floating above it. Out of the portion above the surface, the water quickly drains, and it becomes white as snow."

In respect to the name "anchor ice" being applied to frazil ice, this is due, in the case of water-power developments, to the action of the frazil under certain conditions. Where the head-race of a development is open, allowing the frazil direct access to the intake without having to pass under an ice sheet, it practically becomes anchor ice, because as it comes in contact with the racks and intake structure it adheres to them and rapidly cuts off the water. Under these conditions there is no difference between anchor and frazil ice, once the latter has become attached to the structures. As a matter of fact, it is this action of the frazil which causes the trouble, directly to plant operations, as it is generally formed in the greatest quantity. The action of the anchor ice proper is to cut off the flow of water in the stream bed; when the anchor ice is floating, the conditions are improving.

Winter Conditions.—One condition which requires the attention of hydraulic engineers is the effect of ice upon the discharge of the river, for the formation of frazil and anchor ice in the bed of these rivers and streams has a very marked influence upon their discharge. Lying, as they do, at considerable elevations, the temperature obtaining during the winter months is low and, owing to the steep slope of the streams, their flow is turbulent, thus the necessary conditions are present for the formation of frazil ice. The conditions for the formation of anchor ice are also good, for in many places the stream is too swift to allow an ice sheet to be formed. The water is clear and generally shallow, the nights are cloudless and cold; in consequence anchor ice is formed in great quantities.

The formation of frazil and anchor ice in the mountain streams causes their discharge to be very fluctuating, and accentuates the variation in flow during the low-water period.

Winter Conditions as Affecting Plant Operation.—The successful operation of a water plant in winter, on the rivers of Canada, depends in a large measure on the method of providing for or eliminating the ice troubles which are always to be met with.

In the foregoing, the conditions favorable to the formation of the several kinds of ice to be met with have been explained, also the relation of one kind of ice encountered, to another. Of the three principal kinds, sheet or board ice is the least detrimental to operation; in fact if board ice were the only kind to be dealt with, the trouble would be negligible. Where the channels are small, however, and where anchor and frazil have been formed above, great trouble may be experienced, due to the lodging of this frazil and loosened anchor ice, under the sheet, for frazil ice, in the presence of sheet ice, attaches itself to the under side of the latter, and where the channels are small, the whole flow of the stream may become blocked, overflow will then occur and a great proportion of the stream flow be lost.

One of the best methods, however, of avoiding frazil and anchor ice troubles, is by obtaining a pond of sufficient size and depth in the immediate vicinity and above the intake of the plant, which will readily freeze over. The ice sheet obtained will, to a great extent, eliminate any troubles with frazil or anchor ice.

If the entrance to the power plant is a channel restricted in size, the ice sheet will be a hindrance, rather than a benefit, if there is open water above. In such a case it is much better to be without a sheet of ice, and instead make provision for handling the accumulation of frazil and anchor ice in the head works. There have been many attempts made to deal with this problem, but it generally degenerates into a brute force combat. In many plants provision is made for passing masses of frazil ice through the wheels by raising the racks in sections, currents are then induced to pass across the face of the racks, so that the floating ice, etc., may be carried off.

The great trouble with frazil ice is due to its freezing on the racks and the wheels, finally stopping the supply of water. With regard to the racks, this has been usually due, in a large measure, to the fact that the upper ends of the bars composing them have been left protruding above the water for 2 or 3 feet exposed to the very cold air. In such a position these bars become chilled to the bottom, and even when only cooled to two or three one-thousandths of a degree below freezing point, it is sufficient to cause the frazil ice to adhere to the bars and commence the clogging process. This trouble may be eliminated to a great extent by making the upper part of the rack of wood, and keeping the metal bars entirely submerged, thus preventing the conduction of heat from bars to the atmosphere, and the consequent cooling below freezing point. Besides this method of submerging the metal of the racks, schemes have been brought forward for heating them, such as using hollow bars through which steam may be driven. In many plants instead of this, the head works are housed and heated, not only to provide a good working room for the men fighting the ice, but also to prevent the subcooling of the racks. One of the most successful schemes has been that employed by one of the plants in Ottawa. There the tops of the bars are encased with sheeting, steam pipes being also enclosed. By this means ice troubles have been prevented to a great extent. The use of a live steam jet in the wheel case and guide vanes to prevent the freezing or clogging up of the wheel entrance has been quite successful in several plants.

Editorial

FIXED CARBON TEST.

In view of the interesting series of articles on the fixed carbon test which *The Canadian Engineer* was fortunate enough to secure, some months ago, from a number of the leading bituminous experts in the United States and Canada, it is interesting to note that the City of Toronto has raised the limit for fixed carbon from 15% to 18%. For several years the works department of Toronto has insisted on a low limit for fixed carbon, but in the specifications issued for the supply of 1915, the limit is 18%.

After the appearance of the above-mentioned articles, the works department announced its intention of making an exhaustive investigation into the subject, in order to have more data upon which to base their future requirements in regard to this test. Pressure of other work, however, has prevented the department from making the investigation planned; but it was decided to raise the limit anyway, as there was a general feeling in the department that 15% was too low a limit, especially for asphalts refined from Mexican crudes. The department is of the opinion, however, that the fixed carbon test has value, and that some limit should be imposed in this regard by asphalt specifications.

BOW RIVER POWER POSSIBILITIES.

An extremely valuable report, known as Water Resource Paper No. 2, has recently been issued by the Water Power Branch, Department of the Interior, Canada. It covers investigations carried out on the upper waters of the Bow River by Mr. M. C. Hendry, chief engineer in charge of surveys, under the direction of Mr. J. B. Challies, Superintendent of Water Powers. This river was the first of the Rocky Mountain streams to be investigated by the Department as to its power-producing and storage possibilities. The work was commenced in April, 1911, and carried out with the consulting advice of Lieut.-Col. C. H. Mitchell, C.E., one of the board of consulting engineers to the Dominion Government. The present report covers the work for 1911-12-13, the study having been then completed.

The conservation of the waters of the Bow River is vital to the agricultural and industrial prosperity of a very large area of Southern Alberta. The investigation, with usefulness for irrigation and power purposes in mind, has furnished the Water Power Branch with some most valuable data relative to storage possibilities, climatic conditions, industrial development and meteorological phenomena of wide scope, and with all other essentials necessary for a complete knowledge of the area and its characteristics.

These investigations show that it is economically feasible to regulate the flow of the river, and that by means of six power sites, *viz.*, Kananaskis Falls, Horseshoe Falls, Bow Fort, Mission, Ghost and Radnor, to provide over 48,000 continuous 24-hour wheel horsepower, all within 50 miles of Calgary, as against 19,800 wheel horse-power from the natural flow. The study also shows that the utilization of these waters for power purposes above Calgary need not conflict with the consumption of the same water below Calgary for irrigation purposes. On the contrary, the proposed power regulation would be found of distinct advantage to the extension of existing irrigation systems to their ultimate capacities, and also insure in the future the instigation of additional irrigation projects.

The investigation has been similar to others that have been carried out, or are in progress, in Canada, the United States and other countries. The Hydro-Electric Commission of Ontario has made very extensive studies in this respect, on water powers in the province. There is a difference, however, between the two investigations, in that the latter has been carried on with the object of ascertaining what could be done in the way of power production by the Commission, whereas, the investigations of the Water Power Branch have been with the object of supplying information to the public, and procuring information upon which the best administration of the water powers could be based. Other extensive studies have been those of the United States Geological Survey, among which might be mentioned the investigations in states of New York, Maine, Minnesota, and Washington.

THE VENTILATION OF RAILWAY TUNNELS.

The Committee on Roadway of the American Railway Engineering Association has submitted a finding to the effect that the most practicable, effective and economical artificial ventilation for tunnels carrying steam-power traffic is to be obtained by blowing a current of air into one end of the tunnel for the purpose of removing, or of diluting and removing, the smoke and combustion gases at the opposite end. As practised in America, this way of procuring ventilation partakes of two methods:

(*a*) To blow a current of air in the direction the train is moving and with sufficient velocity to remove the smoke and combustion gases ahead of the engine;

(*b*) To blow a current of air against the direction of the tonnage train with velocity and volume sufficient to dilute the smoke and combustion gases to such an extent as not to be uncomfortable to the operating crews and to clear the tunnel entirely within the minimum time limit for following trains.

PRODUCTION OF STEEL DIRECT FROM ORE.

The conclusions reached in a paper by E. Humbert and A. Hetbeg, before the Iron and Steel Institute, are: That the economic manufacture of steel from ore is quite practicable; that the product, on account of its comparative freedom from hydrogen, nitrogen, and other impurities, is superior, especially in toughness, to steel obtained by present methods; that the electric furnace employed should be of a type permitting violent ebullition of the bath without overflowing; that either charcoal, coke or anthracite may be used as fuel; and that anthracite electrodes will probably be most economical.

Tests were made by the writers, with swedish and Brazilian iron ores in a Héroult electric furnace of 6 tons capacity, using coke as fuel.

ENGINEERS' LIBRARY

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer.

CONTENTS.

BOOK REVIEWS.

Carnegie Pocket Companion. Issued by the Carnegie Steel Company, Pittsburg, Pa. Bound in flexible morocco.

This is the sixteenth edition of the Carnegie Pocket Companion, which has been rewritten and reset throughout. The date of the last edition was 1903. Since that time, the art of bridge and building construction has changed a great deal, while the use of steel has extended into other lines than those covered by the previous edition. In the present publication obsolete forms of construction are eliminated, and the information tabulated is brought up to the present date and present-day practice.

Steel Construction—A Text and Reference Book Covering the Design of Steel Framework for Buildings. By Henry Jackson Burt, C.E. Published by American Technical Society, Chicago, 1914. 381 pages; profusely illustrated; $4\frac{1}{2} \times 7$ inches; flexible binding. Price $2.75. Reviewed by A. E. Davison, B.A.Sc., Hydro-Electric Power Commission of Ontario.

As mentioned in the introduction and largely repeated on page 2 of Part I., "This book is intended to give its students the facts and formulas needed in designing structural steel framework for buildings—accompanied by explanations of the underlying principles. The use of formulas is shown by illustrations of a practical nature, which serve not only to teach the proper application, but to illustrate current practice in this form of construction."

The earlier pages of the book are sufficiently carefully written to permit of anyone, with a reasonable control of mathematics, making practical calculations as outlined, intelligently. Referring to page 38 where "Radius of Gyration" is treated, we find that the information is scarcely as full as an ordinary student might require; that is, actual design practice will not proceed very far until it is necessary to calculate the "Radius of Gyration" for a made-up section such as cannot be taken readily from tables. The text at this point leaves considerable to be determined elsewhere by the student.

On pages 46 to 50, etc., an attempt is made to place the student designer in touch with the urgent need of a thorough understanding between the designer and inspector. In this regard the information on comparative elongation and reduction of area might have been given more attention; for instance, beginners are not generally familiar with the source of empirical data "Elong. 1,400,000/Ult." as indicated on page 50.

Safe units are always a trouble to the student as these may be readily confused with ultimate strengths. We find that in giving data on page 52 the writer, while speaking of "Ultimate Bearing" and "Bearing Values" states "Values below expressed in pounds per square inch taken from the building ordinances from the City of Chicago"; these, of course, are safe load values.

Part II., page 75, etc., deals with practical applications. On this page the matter of "needle" beam with which a new designer soon comes in contact is not mentioned.

On page 94 an attempt is made to give the moment values for a number of different types of beam loading. This tabulation along with those on page 190, etc., save considerable time for the average designer.

In the treating of cast iron columns as on page 232, etc., very little attention is given to the difficulty of lining up a column having a considerable number of splices at floor levels without causing failure at column flanges. Combined stresses with which the ordinary designer has to deal constantly, are briefly treated on page 266, and the matter of the relation of designer to inspector as mentioned above is brought up again on page 370.

Foundations. By Malverd A. Howe, C.E., Professor of Civil Engineering, Rose Polytechnic Institute. Published by John Wiley & Sons, New York; Canadian selling agents, Renouf Publishing Co., Montreal. First edition, 1914. 110 pp.; 55 illustrations; 6 x 9 in.; cloth. Price $1.25 net.

This is a text book on ordinary foundations, including a brief description of the methods used for difficult foundation work. The fundamental principles upon which proper design is based are stated in an elementary way. Separate treatment is given to the foundation proper and to the footing courses of walls and columns. As stated in the preface, many books do not show a marked line of division between the two.

The work is divided into six chapters, as follows: Supporting capacity of soils; wall footings and column footings; piles and pile foundations; chimneys and towers; bridge piers and abutments; and, methods employed for difficult foundations. The book is concluded with an appendix devoted to formulas and nomenclature. An exceedingly useful addition to each chapter consists of a carefully selected set of references, about twenty to each chapter. These refer chiefly to articles that have appeared in the technical press on the subjects under study.

The book will be found exceedingly useful as a text. Its illustrations refer to actual structures, and, although it contains little descriptive matter in the text itself, the references provide the student with a valuable source of

information for the details of any portion to which he may desire to give further study.

Rapid Earthwork Calculation. By C. E. Housden. Published by Longmans, Green & Co., London. First edition, 1914. 31 pp.; illustrated; size 4¾ x 7¼ in.; limp cloth. Price 50c. net.

The author of this book has published several small volumes on earthwork, water supply, drainage, sewerage, etc., that have been found most useful by the practical man in the solution of every-day problems in these branches of engineering. The present work will be found of similar service, as a number of improvements in earthwork calculation are found embodied in it.

In his preface the writer states, "With so many tables already in existence for a similar purpose, new ones may at first sight appear unnecessary and superfluous; actual trial will, however, prove that earthwork quantities can be estimated from them, as within explained, more quickly and with less labor than in any other way."

The tables give the end areas in square feet of bank and cut sections for their side slopes S and S′ to 1 added together, for values of 1, 1½, 2, 2½, 3, 3½, 4, 4½, 5, 6, 7, 8. The text explains how the tables are framed and their application.

Engineering Problems, Part I. By W. M. Wallace, Wh.Sc. Published by the Technical Publishing Co., London. First edition, 1914. 192 pp.; well illustrated; size 5 x 7 in.; cloth. Price 75c. net.

The author gives a collection of rules, relations and data on which are based the more usual calculations in some phases of engineering work. This takes up the opening pages of the text, and is followed by questions and answers illustrating the application of these rules, etc., to practical cases. No method of classification under different branches of engineering has been attempted by the author, and several branches appear to have been entirely ignored. The volume contains, however, some very interesting problems in machine design and in bridge work, while occasionally one encounters an isolated problem, such as earth pressure on a retaining wall, calorific value of petrol, strength of wooden spar, etc. One finds it necessary to state, however, that the subject matter of the book is hardly commensurate with the title chosen for it.

Steam Charts. By F. O. Ellenwood, A.M.Am.Soc.M.E., Professor at Cornell University. Published by John Wiley and Sons, New York; Canadian selling agents, Renouf Publishing Co., Montreal. First edition, 1914. 91 pp.; illustrated; 7¼ x 10 in.; cloth. Price $1.00. Reviewed by A. S. L. Barnes, Hydro-Electric Power Commission of Ontario.

The title of this book is better chosen than is frequently the case, for it gives a real indication as to what the book is—primarily, a collection of steam charts. These charts have been very carefully prepared and the book as a whole "intended to be of assistance to engineers and students when making calculations involving wet or superheated steam," should fulfil its mission without difficulty. An introduction dealing with "Fundamental Principles" forms a brief explanation of the main theoretical points to be dealt with by the steam engineer. The next section deals with the steam charts themselves and explains how they were prepared and how they should be used.

Following this is a short chapter setting forth how to make barometer corrections. There are corrections to be made for temperature, altitude, gravity and capillarity. Even the expansion and contraction of the scale must be taken into account, if a full length brass scale be used. Next come the charts themselves, of which there are nine. These are plotted to a very convenient scale and are exceptionally clear.

On the ordinates is given the total heat of the steam in B.t.u. per lb., while the abscissæ show the specific volume in cu. ft. per lb. Lines of constant pressure are plotted, as also are those of constant superheat. Lines of constant entropy and of constant quality are shown.

To simplify the using of the charts an index chart is given at the beginning of this section from which the range of the main charts can be readily seen and the correct chart thus easily chosen. In range the complete set of charts are amply sufficient to cover present practice.

The conclusion of the book proper consists of a considerable number of problems involving the use of the various charts and tables given, while the closing pages contain an index.

It is evident that a good deal of care has been spent in the preparation of this book in order to present the information in as useful a form as possible and the author may be congratulated on the result. To quote a couple of the problems will perhaps indicate better than anything else the purpose of the book.

"Find the total heat, volume, entropy, temperature, and heat of the liquid of a pound of steam having an absolute pressure of 180 lbs. per sq. in. and a quality of 98%."

All the items here asked for can be ascertained directly by reference to Plate 1 b.

"The Parsons turbine at the Fiske Street station of the Commonwealth Edison Co., Chicago, has an exhaust opening to the condenser of 252 sq. ft. If the water rate for a back pressure of 1 inch of mercury and a load of 25,000 kw. is 11.65 lbs. per kw. hour, find the velocity, through this opening, assuming the steam has a quality of 80%."

From Plate 6 b the specific volume of exhaust steam under the conditions stated is found and the velocity in ft. per min. is calculated directly by dividing the volume of steam by the area of the exhaust opening.

American Society for Testing Materials, Year-Book, 1914. Edited by Edgar Marburg, Secretary, and published by the Society.

This year the Year-Book includes the standard specifications adopted by the Society for steel, wrought-iron, pig iron, cast iron and finished castings; lime, cement and clay products; preservative coatings; road materials; timber and miscellaneous. Tentative specifications are given for coal drawn steel, quicklime and hydrated lime. Another section of the book is devoted to selected specifications from miscellaneous sources, chiefly American Railway Engineering Association; United States Steel Products Co., and the Association of American Steel Manufacturers. There is a special classification included of standard specifications applicable to locomotives. The volume closes with a valuable index of standard specifications.

Percentage Trigonometry. By John Coleman Fergusson, M.I.C.E. Published by Longmans, Green & Co., London. First edition, 1914. 155 pp.; 60 illustrations; size 6 x 9 in.; cloth. Price $1.25 net.

The author has in print a large volume entitled "Fergusson's Percentage Unit of Angular Measurement," which comes at a comparatively high price. Owing to this the present work has been published with a view to

provide at a low figure a book descriptive of the method of using the percentage unit in plane trigonometry. It is written especially for students and navigators. A considerable portion of the book is taken up by a description of how to use Fergusson's Percentage Compass.

The Calculus for Engineers. By E. S. Andrews, B.Sc., and H. B. Heywood, D.Sc. Published by Scott, Greenwood & Son, London. First edition, 1911. 284 pp.; 102 illustrations; size 4½ x 7½ in.; cloth. Price $1.25 postpaid.

This little work is published as Volume 8 of what is known as The Broadway Series of Engineering Handbooks. The importance of a working knowledge of the calculus is no longer a subject for controversy among engineers. The result has been the publication of many text books, more or less modified from standard courses, and prepared in conformity with engineering subjects. In this work, however, the writers endeavor to treat engineering calculus as a subject by itself, and the student will readily appreciate the value of this method when he undertakes to peruse its contents.

The text is supplemented with a number of exercises to test the student's knowledge of the various sections as he goes along. Many examples are specially designed as problems of particular interest to civil, constructional, mechanical, or electrical engineers, as the case may be. Further, the authors have arranged the work in such a way that students may deal systematically with the entire book, or may devote their attention to a shortened course, carefully selected.

Surveying Manual. By Howard Chapin Ives, Professor of Railroad Engineering, Worcester Polytechnic Institute. Published by John Wiley & Cons, New York, London; Canadian selling agents, Renouf Publishing Co., Montreal. First edition, 1914. 296 pp.; size 4¼ x 6¾ in.; illustrated; flexible leather binding.

This manual has been written for first-year students in surveying, with particular adaptation to the needs of mechanical, electrical and chemical engineers, and students in architecture and agriculture. It describes, with illustrations, each instrument, separate chapters being devoted to the chain and tape, the level, the compass, the transit, and another chapter to the aneroid barometer and the planimeter. The practice is very carefully discussed, the subject matter being arranged, in addition to the above chapters, under the following heads: Topographical surveying; railroad curves; computations; plotting; latitude; longitude and azimuth; and large surveys. There is also a chapter descriptive of the U.S. method of laying out public land. A distinctive feature of the manual is that the chapters are divided into sections, each outlining and solving a complete problem. These are replete with sample field notes and carefully explained methods and suggestions.

The information is supplemented by 100 pages of surveying tables, such as are required for ordinary work.

Cast Iron and Steel Pipes: Some Considerations Regarding. By John Sharp, M.I.Mech.E. Published by Longmans, Green & Co., London, Eng. 142 pp., with diagrams; size 6 x 9 ¼ in.; cloth bound, first edition. Price $1.25 net.

Probably in no previous publication has there been presented such scientifically compiled data regarding cast iron and steel pipes. The mathematics in which the book abounds is handsomely presented, and arranged, for the most part, quite logically. In some instances, however, the writer might be accused by many engineers of being biased in his calculations, and in parts the mathematical deductions appear to be derived from doubtful, or at least empirical, presumptions. The various problems are very well treated from a mathematical standpoint, however, and the whole book is well worth reading by engineers, especially as it is being sold at a very low price, considering its excellent typography and fine quality of paper, although readers will possibly be inclined not to accept some of the deductions without personal investigation or the confirmation of past experiences.

Altogether the book is certainly an important one and will probably involve as much discussion and argument in engineering circles as any other book published this year. After discussing the physical and chemical properties of cast iron, wrought iron and steel pipes, and giving figures regarding their strength and elasticity, the author calculates the resistance of pipes to bursting, the thickness and strength of pipes, the flow of water and conditions affecting same, interior and exterior corrosion and influences affecting same, electrolysis, etc. One's impression is that there is an obvious effort to extol the merits of cast iron pipe and to depreciate any value that might be attached to steel pipe. This is carried to an extent that may have an unfortunate influence upon the standing of the book as an independent treatise. Nevertheless, the arguments set forth are of great importance, and it is worth while for every municipal, waterworks and gasworks engineer to read the book and then form his own opinions.

PUBLICATIONS RECEIVED.

Department of Agriculture, Alberta.—Annual report for 1913; 260 pp.; 6 x 9 in.

The Lincoln Highway.—Several pamphlets descriptive of the scenic features associated with the scheme.

Poles and Cross Ties.—Canadian production in 1913, compiled by R. G. Lewis, Forestry Branch, Department of the interior.

Weights and Measures.—Bulletin No. 7, issued by Kansas City Testing Laboratory, containing definitions and tables of equivalents.

Preservation of Ties, Poles and Timbers by Antiseptic Treatment—Reprint of the paper read before the Central Electric Railway Association by W. F. Goltra.

Rubber: Wild, Plantation and Synthetic.—Reprint of an article from the Popular Science Monthly, by Dr. John Waddell, School of Mining, Queen's University.

Pulpwood.—A report on the pulpwood manufactured in Canada in 1913. Also on exports and imports. Compiled by R. G. Lewis for the Forestry Branch, Department of the Interior.

Production of Explosives in United States, 1913.—A 15-page bulletin, compiled by A. H. Fay, United States Bureau of Mines, classifying explosives and listing United States production.

Ventilation of Farm Buildings.—Bulletin No. 78, issued by Department of Agriculture, describing the Rutherford system of ventilation, in operation on all its experimental farms and stations.

Prevention of Accidents from Explosives in Metal Mining.—Circular 19, United States Bureau of Mines, prepared by Ed. Higgins, describing dynamite; method of handling explosives; thawing, and blasting by electricity.

Gold Fields of Nova Scotia.—By W. Malcolm, Geological Survey Branch, Department of Mines, Canada. Issued as

memoir No. 20 E., 330 pp.; illustrated; 6 x 9 in. The report includes a summary, general and economic geology, of the various deposits, and statistics of production.

Commission of Conservation, Canada, 1914.—Fifth annual report, containing proceedings of annual meeting, January, 1914, in which is included summary statements of the work done under the several committees of the Commission during the year ending March 31st, 1914. 286 pp.; illustrated; 6 x 9 in.; cloth binding.

Ontario Bureau of Mines, 1914.—23rd annual report containing statistical review, mine production, mining accidents and reports from the Pre-Cambrian rocks north of Lake Huron, the chemical composition of natural gas found in Ontario, and the Kirkland Lake and Swastika gold areas, 340 pp.; 6 x 9 in.; illustrated.

CATALOGUES RECEIVED.

Steam-Jet Air Compressors.—A 4-page leaflet published by Meldrums, Limited, Manchester, England.

Mine Hoist Equipment.—A 32-page bulletin issued by the Canadian General Electric Company, well illustrated.

Exide Batteries.—A 24-page catalogue listing type X batteries for automobiles starting and lighting service.

Portable Volt Meter.—A leaflet issued by the Canadian General Electric Company describing type P-8 portable volt meter.

Steam Railroad Electrifications.—Twenty-four pages issued by Westinghouse Electric and Manufacturing Co., describing various electrifications in the United States.

Steam-Jet Elevators.—A 4-page leaflet describing an improved design for lifting and forcing water, acids, etc. Issued by Meldrums, Limited, Manchester, England.

Ice Harvesting.—A 16-page illustrated booklet describing the basin saw and the bond feeder, important auxiliaries for natural ice plants. Issued by Gifford-Wood Co., Hudson, N.Y.

Modern Electric Railway Apparatus.—A handsomely-illustrated 30-page booklet issued by the Canadian General Electric Co., describing railway power apparatus and installations.

Direct Current Sub-Station Equipment.—A Westinghouse bulletin descriptive of high voltage generators, rotary converters and motor generators, as installed on various notable railway systems.

Portable Railway Plants.—A 68-page illustrated catalogue issued by Robert Hudson, Limited, Gildersome Foundry, Leeds, Eng., describing light locomotives, cars, trucks, switches, turntables, contractor's plant, etc.

Vertical Gas Engines.—Twenty-two pages of interesting information descriptive of Browett-Lindley enclosed, forced lubrication, gas engines of various sizes, speeds and powers. Issued by Browett-Lindley & Co., Manchester, England.

Feed Water Problems.—A 20-page leaflet circulated by Canadian Allis-Chalmers, Limited, Toronto, on reducing boiler room costs by heating and softening the feed water. It describes the Sorge-Cochrane hot process system of water softening.

BACK COPIES WANTED.

Requests have been received for a copy of each of the following issues of *The Canadian Engineer*:—November 30th, 1911; December 7th, 1911; and June 12th, 1913. As our supply of these has been exhausted, we will be glad to extend for one month the subscription of any reader who will supply us with any one of them.

Coast to Coast

Point Grey, B.C.—Plans have been sent to Ottawa for approval for a proposed wharf on the north arm of the Fraser River at Eburne.

Quebec, Que.—The reconstruction of the Dorchester bridge will be completed in a few weeks, according to the J. M. Gignac Co., Limited, contractors.

Toronto, Ont.—The temporary trackage now being laid on Bloor Street West from Dundas Street will be completed within a few weeks. The city has decided to operate this new line as a civic car line.

Sarnia, Ont.—The harbor has been dredged to a depth of 22 ft., and survey work by the engineers of the Department of Public Works, will be continued preliminary to construction work that will likely be completed next season.

Cobalt, Ont.—The lowering of the water in Cobalt Lake has progressed to such an extent that by the end of the month the water line will be over 6 ft. below normal. Practically all work in connection with the outlet has been completed.

Vancouver, B.C.—The completion in this city of a new pier and warehouses by the C.P.R., at a cost of $750,000, is one of the steps that are being taken in anticipation of the business expected with the commercial opening of the Panama Canal.

Toronto, Ont.—A memorial highway, 535 miles in length, extending from Windsor to Montreal, is the subject of considerable discussion. It is estimated to cost $3,000,000. Mr. W. A. McLean, provincial highways engineer, suggests a permanent base 9 ft. in width, and estimates the cost at approximately $8,000 per mile.

Bruce Mines, Ont.—Work may be started in January on a 325 miles extension from Bruce Mines northerly, a contract having been let to the Ontario Northern Construction Co., on a percentage basis. The maximum grade north will be 1 per cent., and south .6 per cent. The heaviest curve will be 6 degrees. It is expected that about 50 miles of the line will be completed early next fall.

Penticton, B.C.—The Kettle Valley Railway has been linked up between here and Midway and construction work is well advanced towards Princeton, where the line will join the V. V. & E., and use a joint section to Otter Summit, where connection is made with the Nicola branch of the C.P.R. Construction work is now well advanced on the Kettle Valley bridge on the line linking the new Hope Mountain route with the C.P.R. on the north side of the Fraser. Grading has also been completed on the Hope-Coquahalla Summit section of the Hope Mountain route, and it is anticipated that the new line will be ready for traffic to the coast next summer.

Toronto, Ont.—The announcement that the Hydro-Electric Power Commission of Ontario is making a survey of the route of the Ontario West Shore Railway between Kincardine and Goderich, recalls to mind the noted case of the would-be engineer and capitalist, John W. Moyes, who has managed to escape, up to the present, the arm of the law, while a score of municipalities in the counties of Huron and Bruce are paying interest on a multitude of worthless bonds. The engineers of the Commission went out last week to appraise the line and to make an estimate of the material on hand. It is understood that they will report upon the eligibility of the route with a view to incorporating it in the provincial radial scheme. It will be remembered that a little grading had been done before the windup of the ill-fated scheme.

PERSONAL.

H. THOMPSON has been appointed electrical inspector for Belleville, Ont.

CHAS. JOHNSTON has been appointed assistant engineer on the Toronto-Hamilton highway.

G. J. SMITH, of St. Catharines, has been chosen by the Hydro-Electric Power Commission as electrical inspector for that city and district.

J. M. WILSON, formerly assistant resident engineer at Toronto for the Department of Public Works, succeeds Mr. J. G. Sing as resident engineer.

A. W. ELLSON FAWKES, until recently waterworks engineer for the city of Calgary, has opened an office and will carry on a general engineering practice in that city. His address is Burns' Building.

W. E. BRADSHAW, of the Dominion Bridge Co., lectured the Engineering Society of the University of New Brunswick on the design and construction of the new bridge over the Reversible Falls at St. John.

J. G. SING, for many years resident engineer in Toronto for the Department of Public Works, Canada, has resigned, and will continue his practice of consulting engineer. He will also retain his position as consulting engineer to the Toronto Harbor Board.

ARTHUR SURVEYER, Consulting Engineer, Montreal, read a paper before the Electrical Section of the Canadian Society of Civil Engineers on the 19th inst., entitled "Making our Water Powers Valuable." The paper is extracted elsewhere in this issue.

ROBERT W. ANGUS, Professor of Mechanical Engineering in the University of Toronto, and consulting engineer to the city on the Victoria Park water proposal, addressed the Royal Canadian Institute last week. He traced the city's campaign for a better water supply, and described in detail the Victoria Park proposal.

SIR ADAM BECK, chairman of the Hydro-Electric Power Commission of Ontario, gave an illustrated address to the members and friends of the University of Toronto Engineering Society on November 18th. The subject was a general review of the work of the Commission with particular attention to the hydro-electric developments at Wasdell's Falls and Eugenia Falls, Ont. Mr. F. A. Gaby, chief engineer of the Commission, addressed the Society on the technical features of these developments.

GEORGE J. BURY has been appointed vice-president of the C.P.R. to succeed Mr. David McNicoll, resigned. Mr. Bury is a Montreal man, 48 years of age. He joined the C.P.R. as a clerk in 1883, and has since filled the following positions:—Assistant superintendent in charge of division, Chalk River to Cartier and the Soo; superintendent at Fort William; superintendent at Cranbrook, B.C.; assistant general superintendent Lake Superior division; general superintendent of that division; general superintendent of the western division, with headquarters at Winnipeg; vice-president and manager of western lines (1907), and vice-president (1911).

DAVID McNICOLL, who has recently resigned the vice-presidency of the C.P.R., owing to ill-health, will remain on the board of directors of the company. Mr. McNicoll was born in Scotland in 1852. He entered the service of the North British Railway in 1866, and went to the Midland in 1873. He came to Canada shortly after and in 1874 became a chief clerk for the Toronto, Grey and Bruce. He was general passenger agent, 1882-3; from 1883-9 was general passenger agent of the eastern division of the C.P.R., then till 1896 general passenger agent of rail and steamship lines of the C.P.R. Later he became passenger traffic manager, and in 1899-1900 was assistant general manager, becoming vice-president and general manager in 1900. He held this position till 1903, and has since been vice-president and one of the directors of the company. Mr. McNicoll is also president of the St. John Bridge and Railway Company, and a director of the Molsons Bank.

OBITUARY.

Mr. J. S. Ferguson, of the Northern Development Branch of the Ontario Service, died suddenly at North Bay, Ont., last week. Mr. Ferguson was 50 years of age, and for the past three years had been associated with Mr. J. S. Whitson on road construction in Northern Ontario.

The death has been announced of Hon. Wm. Templeman, former minister of mines and of inland revenue for the Dominion Government. Mr. Templeman was also a member of the Royal Conservation Commission in 1909.

CALGARY BRANCH CANADIAN SOCIETY OF CIVIL ENGINEERS.

Mr. William Pearce, M. Can. Soc. C.E., executive assistant, Department of Natural Resources, C.P.R., gave a very interesting address before the members of the Calgary branch of the Canadian Society of Civil Engineers, on Friday evening, the 6th instant. The speaker made a trip around the world about two years ago, and made a special study of irrigation and forestry, in foreign countries. On Friday evening he chose as his subject "Irrigation in Egypt," and, in a very interesting manner, described the various irrigation and other engineering works there. His numerous observations on the habits and manners of the people, the various means of transport, etc., were also very interesting.

The annual meeting of the Branch and the election of officers for the ensuing year will be held on Saturday, December 5th.

COMING MEETINGS.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.

AMERICAN ROAD BUILDERS ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.—Annual Convention to be held at the King Edward Hotel in Toronto, January 26, 27, and 28, 1915. Secretary, G. C. Keith, 32 Colborne Street, Toronto.

EIGHTH CHICAGO CEMENT SHOW.—To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.

AMERICAN WATERWORKS ASSOCIATION. — The 35th annual convention, to be held in Cincinnati, Ohio. May 10th to 14th, 1915. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—Annual meeting to be held at the Iowa State College, Ames, Iowa, June 22nd to 25th, 1915. Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Volume 27. Toronto, December 3, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

STREAM FLOW INVESTIGATIONS

NOTES ON METEOROLOGICAL PHENOMENA WITH REFERENCE TO GOVERNMENT POWER AND STORAGE INVESTIGATIONS OF THE BOW RIVER—FROM REPORT OF M. C. HENDRY, CHIEF ENGINEER.

THE various relations which exist between precipitation, altitude, run-off, temperature, evaporation, etc., make the study of stream flow exceedingly complex. While the influence of each is not in all cases a direct one it is frequently of such magnitude that to regard it lightly leads to inaccuracies of serious nature. In hydro-electric development work all factors influencing the discharge of the river or stream demand closest investigation over a period of years in order that their valuable characteristics may be measured to a degree providing mathematical limits within which lie the data to form the basis of the proposed design. The value of an exhaustive study of these physical characteristics and their causes, is rightly emphasized by Mr. M. C. Hendry in his recent report on the power and storage investigations of the Bow River. These investigations were made by him under the direction of Mr. J. B. Challies, Superintendent of Water Powers in the Dominion. In our issue of last week the work which the Water Power Branch has accomplished on the water resources of the Bow River basin was chiefly outlined. The following notes respecting meteorological phenomena are from the above report.

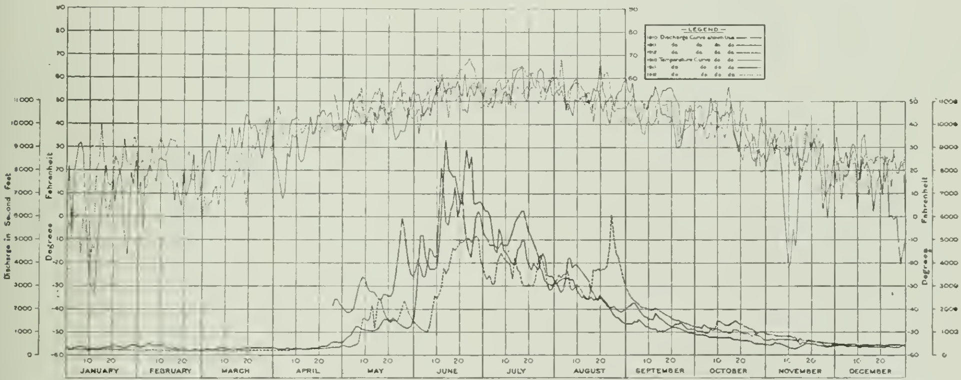


Fig. 1.—Daily Discharge and Mean Temperature, Bow River, Banff, Alta.

The importance of a study of precipitation in connection with the flow of streams cannot be emphasized too much; its influence on stream flow is a very direct one and, without study, the erroneous conclusion is reached that the relation between precipitation and run-off is a simple one. A little time spent in the study of the question soon reveals the fallacy of this assumption, for the relationship is anything but simple, being influenced by a great many physical features of a rather indeterminate nature.

The collection of precipitation data all over the country has been carried on for a comparatively long term of years, whereas data regarding the run-off of streams are rather meagre. If, therefore, some general relation can be established between rainfall and run-off, the study of the streams from the standpoint of power production can be placed upon a more satisfactory basis. In the West, run-off data have been collected for a very short term of years, and only during the last three has a continuous record of the discharge been kept; thus the importance of a general relationship between recorded precipitation and run-off is all the more apparent.

The distribution of rainfall in any district or part of the country is not uniform. The records throughout Canada, generally, except in the eastern provinces, do not extend over a sufficiently long period, nor are the stations widely enough scattered to define areas in which certain amounts of rainfall may be expected. In the West, an examination of the available records seems to indicate a general conformation to conditions found to the south, in the United States; that is, that the lines of equal rainfall are generally north and south, or roughly parallel to the mountain ranges. There are, of course, divergences due to local influences.

Relation of Precipitation to Altitude.—Generally speaking, precipitation decreases with the increase in altitude. It has been found in travelling westward away from the Atlantic that as the country rises, the rainfall decreases. This general rule, however, does not seem to apply to the precipitation in the valley of the Bow River; in fact, the direct opposite is apparently the case in practically all the territory forming the eastern slope of the Rockies. An examination of the records will show that as the altitude increases on the eastern slope, the precipitation increases. Special local influences are at work here, however, the mountain ranges in which are situated the sources of the rivers, causing this reversal of the general rule.

The warm, moisture-laden winds from the Pacific are first intercepted by the mountains of the Coast range and deflected upwards to mingle with cold air currents or to come in contact with land at a lower temperature; becoming chilled below the temperature of saturation, they deposit some of the moisture as snow or rain as they pass over the mountains, giving rise to the heavy precipitation near the coast, the greatest recorded on the continent.

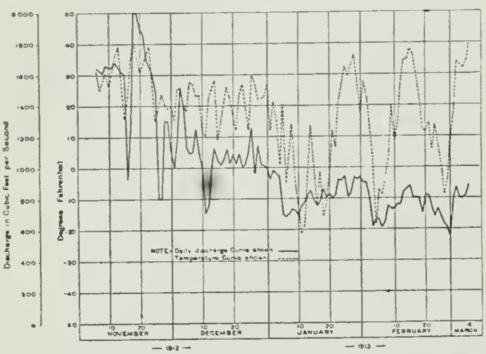


Fig. 2.—Daily Discharge (at Horseshoe Falls) and Mean Temperature (at Banff, Alta.), Bow River.

They then pass over a stretch of low-lying land, depositing but little moisture until the Selkirk range is reached, where the process is repeated. When the Rocky mountains are reached the humidity of the air has become much reduced, but the low temperatures reached at the higher altitudes is sufficient to cause more precipitation; there fore, in the Bow River basin, with which we are dealing and which is on the eastern slope of the Rockies, it is at the higher altitudes that the greatest precipitation occurs. The alteration of mountain ranges with stretches of country of low altitude is accepted as the cause of the arid and semi-arid regions to be found to the east of the continental divide.

Value of Records.—In making a study of rainfall in any district, it should be borne in mind that the average precipitation gives only a relative view of the question, as great variation from the average annual precipitation may occur at different points in the district. In this regard no general law can be made to apply. The number of conditions contributing are so great and variable that, for special purposes, a detailed study of the rainfall in the locality is necessary.

When studying precipitation records extending over a given period, it is necessary to know what value may be attached to them. Sir Alexander Binnie has given this question careful consideration in a paper published in the proceedings of the Institution of Civil Engineers (Vol. 109, pages 89 to 172). He reached the conclusion that for records extending over a period of 25 years, the mean obtained would be within 2 per cent. of the true mean. The conclusions reached by Mr. Rafter in a discussion of this paper were: that, for a period of 5 to 10 years, the probable extreme difference from the mean would be 15 per cent., and of 10 to 15 years, 4.75 per cent. Other authorities have expressed the opinion that it is necessary to have records for a period as great as 40 years in order that the mean may represent the true mean precipitation within 5 per cent.

Accuracy of Records.—In Canada, the recording stations are all under the direction of the Meteorological Service, and a standard method of obtaining the records is adopted. It is to be noted, however, that the placing of the recording instruments can have a very great influence upon the accuracy of the records. To arrive at the average precipitation upon a district, it is necessary that as many records as possible in the area to be considered should be available, as conclusions based upon records from a limited number of stations are liable to be considerably in error. An ideal condition under which to study rainfall data would be attained if the stations were uniformly distributed over the territory, or placed along each branch of the stream of which the relation between run-off and precipitation was to be established.

Distribution of Precipitation.—A study of the periodical distribution of the rainfall is interesting. Generally this distribution throughout the year, from year to year, is fairly constant in any district, but is different in different districts. For instance, there is a similarity in the distribution in the different localities along the Pacific coast; the same may be said of the territory to the east of the Rockies, while that portion around the Great Lakes has its typical distribution.

Tables showing the fluctuation in the annual precipitation recorded at Banff and Calgary have been prepared. At Banff, the records are available at intervals from 1890 to 1896, from which year they are continuous to date; during that period, the maximum precipitation occurred in 1902, 30.59 inches being recorded, and the minimum was 10.33 inches in 1903. The mean yearly precipitation for twenty years is 19.13 inches. At Calgary, the records are available from 1885 to date, during which interval the lowest recorded annual precipitation occurred in 1892, 7.91 inches being the amount; and in 1902, the maximum precipitation occurred, 34.57 inches being recorded. The mean yearly precipitation over the period of 27 years is 16.10 inches.

Owing to the scattered location of the recording stations in the district—at Banff, Calgary, and Jumping Pound (from the latter, only partial records are available)—they do not truly represent the conditions obtaining in the basin.

As has been mentioned before, the precipitation increases in this locality with the altitude. The altitude of the station at Calgary is approximately 3,400, that at Jumping Pound about 4,200, and at Banff 4,525 feet, and an examination of the records will show a greater precipitation at Banff and Jumping Pound than at Calgary, that recorded at Banff being the heaviest of the three. The sources of the Bow River and its tributaries are at much greater altitude than is the gauging station at Banff; in fact the greater part of the drainage area above Kananaskis Falls lies above this altitude, so that the stations are by no means representative of the greater part of the drainage basin.

Relation of Precipitation to Run-off.—If the records of precipitation are compared with those of the run-off on the basin, it will be found that the recorded run-off exceeds the precipitation as recorded at Banff, by as much as 25 per cent. This condition is by no means uncommon for mountain districts. Mr. John R. Freeman, in his report on the Hetch Hetchy water supply for San Francisco, says:—

"In regard to the excess of run-off over precipitation, the fact that depth of run-off exceeded depth of rainfall at outlet simply proves that the average precipitation for the catchment as a whole was far greater than at this comparatively sheltered spot of lower altitude at the outlet of the valley."

This condition holds in the Bow basin, and emphasizes the need of more stations for the recording of precipitation.

On account of the short period over which complete run-off data are available, and the few precipitation recording stations in the catchment area, no definite relation can be established between run-off and precipitation. The only conclusion that can be arrived at from a study of these data is that for the water years from 1909 to 1911, the mean precipitation has been nearly equal to the mean yearly precipitation for the last sixteen years, as recorded at Banff. It is fair, therefore, to assume that the run-off during the same years represent approximately the mean run-off conditions during a like period.

Division of the Year.—In considering the relation of precipitation to run-off, a period known as a "water year" is made use of, instead of the calendar year. This period for the Bow Basin district may be assumed as extending from October 1 until September 30, for practically all of the water is obtained from the mountains, and from October 1 on, the precipitation in the form of snow is stored in the mountains to be held until the warm sun of the following early summer releases it, to form the summer freshets which occur during May, June and July.

Temperature.—Temperature in the Bow River drainage area is one of the great factors influencing the discharge of the river. In the upper part of the catchment area there is not a month in the year in which frost cannot be expected. The range of temperature is great, the range of mean temperature at Banff is from $56^\circ.9$ in July to $13^\circ.7$ in January, or $43^\circ.2$ of difference; at Calgary, the range of mean temperature is from $70^\circ.7$ in July to $14^\circ.2$ in January, or a range of $66^\circ.4$; and the maximum and minimum temperature greatly exceed these. From these two records it will be seen that the one at the higher altitude registered the lowest temperature. At the higher altitudes it is to be expected that low temperatures will be encountered, and that the period during which conditions of low temperature obtain will be longer than at the lower levels. The records are taken at an altitude which is low, considering the drainage area of the Bow River as a whole, and hence do not represent truly conditions in the upper part of the valley of that river. They give, however, an indication of the conditions to be found and, upon study, reveal some interesting facts with regard to the bearing of temperature upon the discharge of the river.

Influence Upon Evaporation.—The influence of temperature upon evaporation is one which is constant and unmistakable, but is one for which, so far, no relation has been established. Sufficient data are not available for a study of the question in the district, but in passing it seems well to note the work that has been done in this regard, and which is well summed up in a paper by Mr. Rafter, published by the United States Geological Survey. In this paper Mr. Rafter had made a careful analysis of the available data, and he reached the conclusion that no definite relation exists between evaporation and temperature, but that the influence is a constant one, and cannot be disregarded.

Influence of Temperature on Discharge.—There is no other single condition which plays such a vital part, or has such a direct influence upon the discharge of the rivers of the district as temperature. A diagram (Fig. 1) has been prepared, showing graphically this relationship—the daily discharges of the Bow River at Banff have been plotted continuously, and on top of this has been plotted the mean daily temperature as recorded at Banff from April, 1910, to December, 1912. Another diagram (Fig. 2) has been prepared for the period November 6, 1912, to March 6, 1913, showing the mean daily discharge for the Bow River at Horseshoe Falls, and the mean daily temperature as recorded at Banff.

A study of these diagrams will reveal how direct is the influence of temperature upon the discharge of the river; during months of low temperature the discharge is shown to be low. On the other hand, high temperature corresponds to large discharge, although within the limits of the record, the highest temperatures occur in the month following the highest discharge. This can be explained by the fact that, except upon the mountains permanently covered, the snow has nearly all been melted during June and the early part of July.

The second diagram shows clearly that the influence of low temperature on the discharge is unmistakable. The period selected is that covering the low-water stage of the river, which corresponds to the period during which extreme low temperatures are most encountered throughout the interval covered by the curve. It will be noted that the mean temperature is above freezing on only eighteen days, consequently it affects not only the source of the river but also the actual flow in the river itself.

PORT ARTHUR WATER SUPPLY.

The new water supply for the city of Port Arthur, Ont., was turned on last week. The installation includes two 24-inch steel intake pipes supported by piles and extending from a point in the lake 2,550 ft. from the shore, and in 45 ft. of water, to a well at the pump house. The intake is 10 ft. above lake bottom. The plant is equipped with 3 pumps each of 2,880,000 gallons per day capacity. Each pump is operated by a 250 h.p. motor. Two 24-inch mains extend from the pump house to the corner of McDougall and Algoma Streets, and from here the water is conveyed by 12-inch pipes to the city mains. The 24-inch pipes provide for ample extension of the distribution system as future needs may require.

The system is equipped with a chlorinating plant. As to the quality of the water, the provincial board of health reports it to be free from bacteria, and in every way satisfactory.

The total cost of the work has been $585,000. It was divided into a number of contracts, the chief of which was awarded to the Thunder Bay Construction Co. This contract included the construction of the pumping station, the laying of the intake, and the driving of a 530-ft. tunnel through rock between the pumping site and the lake.

The work has been executed under the supervision of Mr. L. M. Jones, city engineer.

PUBLIC WATER SUPPLY FOR CITIES—SOME GENERAL CONSIDERATIONS.*

By W. H. Dittoe,
Chief Engineer, Ohio State Board of Health.

IN the modern sense the waterworks of a city includes the source of supply and the equipment required to deliver the water through a distributing system to the point where it is utilized. The development of public water supplies in accordance with this interpretation has been of comparatively recent occurrence. In the United States there were only 53 public water supplies in 1850. Since that date, however, the installation of public water supplies has been general and it is estimated that at the present time there are fully 6,000 public water supplies. Prior to the invention of pumping machinery for lifting water the development of water supplies was practically nil. In 1582 in London the first pumps for water supply purposes were placed in operation. An important development in assisting the installation of public water supplies was the introduction of the steam pump in London in 1761. An impetus in water supply development came in the latter part of the 18th century when cast iron mains were introduced as a means of distributing the supply. Previous to that time wooden pipes only had been used.

In the early development of water supplies little attention was given to the quality of the supply. It was not until 1829 that serious consideration was given to the quality of the water. In that year the first filter was installed for the East Chelsea Water Company at London. About 1850 the germ theory of disease was seriously advanced and it was at this time the claim was made that typhoid fever was caused by a specific organism transmitted in sewage. This marked the beginning of the use of filters as a sanitary precaution in the improvement of water supplies, although definite proof of the existence of the typhoid germ was not secured until 1880 and 1881. The early development was the so-called slow sand filter which is still now extensively used in European countries and also in the United States. It was not until 1893 that studies were made leading to the development of the so-called mechanical or rapid sand filter. This process is known as the American system of filtration, although its origin was in England. At the present time it is estimated that there are 350 municipalities in the United States utilizing mechanical or rapid sand filters to purify their water supplies. The slow sand filters have not met with such favor in this country due no doubt to the fact that they are less suitable in the treatment of muddy water. At the present time there are about 50 municipalities using slow sand filters in the United States.

Sources of Water Supply.—The original source of all water is the rainfall which precipitates upon the surface. A portion of this rainfall is absorbed by the soil and percolates into the underlying formations. Another portion flows from the surface through streams and rivers to their points of discharge. An appreciable amount is lost by evaporation and another portion is utilized in the support of plant life. The portions in which we are interested for water supply purposes comprise that which percolates into the soil, becoming a source of ground water supplies, and that which passes off into the streams, becoming a source of surface water supplies.

*Read before Conference of Health Officers, Ohio State Board of Health.

Ground water may be obtained by means of wells, springs, or collecting galleries. Depending upon the elevation of the ground water with relation to the surface of the ground, it will require one or two sets of pumps to deliver it into the mains. The quality of ground water is dependent upon the formations from which it is obtained. Thus, by passage through a limestone formation the water will absorb hardness. If it comes in contact with iron salts, which are almost always present, it will absorb the iron by solution. It may also take on objectionable tastes and odors due to the absorption of sulphur compounds. In general, ground waters are less desirable than surface supplies, judged from their mineral characteristics.

Surface water supplies are derived from streams, lakes or reservoirs. With lakes or large rivers it is unnecessary to provide storage of raw water for a continuous supply for the pumps. With small rivers and creeks, however, it is frequently necessary to construct impounding reservoirs to store a sufficient portion of the excess flow of the stream to serve during dry weather. The quality of surface water supplies is dependent upon numerous factors, the most important of which is the density of population upon the drainage area. Theoretically every dwelling on the drainage area contributes to the pollution of the stream. The degree of pollution is, therefore, determined by the population. It is, of course, possible to reduce the extent of pollution by proper disposal of sewage. Regardless of the treatment of sewage, however, it is generally conceded that no surface supply collected from a catchment area which is populated is safe for drinking purposes without purification. This is particularly true in Ohio and in other densely populated localities where the streams are almost universally used as carriers of sewage.

Conditions Governing Choice of Source of Water Supply.—Statistics of public water supplies of United States show that a large percentage of the supplies are obtained from ground water sources. Practically all of the villages and small cities of Ohio obtain their supplies from wells, springs or collecting galleries. As the population increases, however, it is found that the ground water supplies will not furnish a sufficient quantity of water. Of the cities in Ohio with populations of 25,000 or more, five obtain their supplies from wells and nine are provided with water supplies of surface origin. Four of the well supplies are inadequate and two of them are supplemented by surface water. The indications are that unless unusually favorable conditions are encountered a city of more than 25,000 population must depend upon a surface source of water supply. In any case the most serious consideration must be given to the question of quantity in determining the choice of a ground or surface source of water supply.

It may be stated generally that the fundamental condition governing the choice of the water supply is the quantity available. It is obviously unwise to develop a source of supply which within the life of the installation will fail to furnish a sufficient amount of water. In determining upon the quantity available assumptions must be made to estimate the growth of the city and the increased use of water. The quantity thus determined must be supplied during the most extreme dry weather conditions which can be anticipated. It is not enough to supply a sufficient quantity of water for 350 days of the year and meet a deficiency during the remaining short period.

Of almost equal importance to the question of quality is the quality of the supply. Having two supplies pro-

posed equal as regards quantity available, the quality consideration will determine the selection. Troubles associated with poor quality are not confined to surface water supplies but are also experienced in water from ground sources. With the established modern methods of water purification it is probably true that improvement of the quality of surface water supplies is more easily accomplished than is the improvement of quality of an objectionable ground water supply. In the consideration of quality it is well to give attention to the value of pure water. It has been shown that improvement of the hygienic quality of the water supply fully repays the community in many ways for the expenditure incurred in the establishment of a water purification plant. The saving of lives and reduction of morbidity from typhoid fever alone will reduce the expenditures of the citizens of the community to such an extent as to repay within a few years the financial outlay for a plant. Thus it can be shown that the city of Columbus has saved for its citizens over $500,000 per year since its water purification plant was established. Cincinnati has saved for its citizens $1,750,000 per year by purifying its water supply. In like manner it can be shown that it is economical to provide a soft water supply for a city even at a greater expense than would be incurred in the development of a water supply containing objectionable hardness. Modern standards of purity of a water supply require that its physical hygienic and chemical properties be satisfactory. Using this standard a pure water supply is an asset and an impure water supply an expense to a community.

Another consideration to be given in selecting a source of water supply is the cost of its development. It frequently happens, however, that a source of supply costing more to develop is the more economical selection. It will readily be seen that a supply cheaply developed which does not furnish an adequate quantity is really an expensive selection. It is well to keep in mind that the cost of development is purely relative, and within the financial limits of a community consideration of cost must be subservient to those of quantity and quality.

Purification of Water.—Having decided upon the development of a water supply which is not of satisfactory quality in its raw state, some means must be provided to produce a water of good quality. If the water is obtained from wells it may require aeration, softening and iron removal. The softening of water is expensive in proportion to the original hardness. Few attempts have been made in this country to soften well water supplies of municipalities. Aeration and iron removal are, however, well recognized methods of water treatment to improve the quality of ground water supplies. In Ohio we have about six plants for the purpose of reducing an objectionable iron content.

The purification of a surface water supply may be brought about by one or both of two general methods, namely, filtration and disinfection. Purification by storage and sedimentation has been advanced as an efficient means of correcting the pollution of water supplies but thus far has gained little recognition. Filtration improves the physical quality of the water as well as its hygienic quality. Disinfection removes the pathogenic organisms but does not affect the appearance of the water. It will, therefore, be seen that the field of disinfection as the only treatment is confined to water supplies of good physical quality. There are two well-known methods of filtering water. The first and older process is the so-callled slow sand filter and the other, a more modern method, is the so-called rapid sand or mechanical filter. As has been stated, the slow sand filter is a development of the early part of the nineteenth century, while the rapid sand filter has come into use during the past thirty years. The slow sand filter is more applicable to the treatment of a moderately clear water while the rapid sand filter can successfully treat a very muddy or turbid water. The slow sand filter consists of a watertight basin usually one acre or less in area, provided with suitable underdrains over which is placed the filtering material. In the northerly climates it is customary to provide a roof for the filter. The filtering material comprises three feet or more of sand, resting upon gravel surrounding the underdrains. The water to be purified is applied at the surface of the filter. It fills the voids of the filtering material and stands to a depth of about three feet above the surface of the sand. Its flow through the sand is controlled so that it passes downward at a rate of 0.4 foot per hour, corresponding to 69 gallons per day per square foot of area or 3,000,000 gallons per day per acre of area. This is a low rate of filtration. The water passing through the filter is stored in a reservoir from which it is pumped to the distributing system of the city. The mechanical or rapid sand filter differs from the slow sand filter in the preliminary treatment of the water as well as in the rate of filtration.

The rapid sand filter is a development of the last thirty years. It first attracted attention in 1885, when a plant of this type was constructed for the treatment of the water supply of Somerville, New Jersey. For the first fifteen years it was principally used in the treatment of water supplies for industrial use, such as paper mills and allied industries. In 1902 the first large municipal rapid sand filter plant was constructed for the East Jersey Water Company at Little Falls, New Jersey. Since that time the development of rapid sand filters in the United States has been very important. Among the largest plants in the country may be mentioned those at Cincinnati, New Orleans, Louisville, Columbus, Toledo, Harrisburg, Minneapolis, and Grand Rapids. The cities of Cleveland and St. Louis are now constructing plants of the rapid sand type.

The rapid sand filter plant differs from the slow sand plant in many respects. With the use of a rapid sand plant the water is always given preliminary treatment by a coagulant. It is passed through filters of much smaller area at much higher rates. Roughly speaking, the rate of filtration is forty times that used for the slow sand filter. The filtered water is received and stored in a covered reservoir in the same manner as is the case with slow sand filters. The cleansing of the rapid sand filter is accomplished by a reverse current of filtered water passed upward through the sand removing the layer or silt and coagulant collected at the surface. This differs from the cleaning of a slow sand filter, which is usually accomplished manually or by mechanical means.

The principal features of a rapid sand filter plant are the intake and low lift pumping station, the primary sedimentation basins, the coagulation basins, the filters and the clear well. The raw water is received through the intake, elevated to the primary sedimentation basins by the low lift pumps, and from this point passes by gravity through the plant to the clear well.

Primary sedimentation is required for turbid water carrying large quantities of silt. Thus the Cincinnati and Louisville plants have large basins where the water is allowed to settle for several days before it is passed through the purification plant proper. The use of primary sedimentation basins is not always required.

The coagulation basins are provided with a two-fold purpose, namely, to furnish a period for the reaction of the coagulant in the water, and for partial sedimentation of the suspended matter. The chemicals generally used as coagulants are alum and copperas. Alum, or aluminum sulphate, is readily soluble in water and if applied in proper proportion to the ordinary surface water will form a sticky gelatinous precipitate called the floc, which in its formation collects the suspended matter and bacteria into heavy masses which readily precipitate. The action of copperas, or sulphate of iron, is quite similar, but this compound requires the addition of lime or soda ash to bring about coagulation. Where alum or copperas are used a portion of the coagulant will pass through the coagulation basins to be removed from the water at the surface of the sand in the filters. Coagulation basins are designed to furnish an ample period for the formation of the floc and an additional period for its partial settling. The necessary time required for this purpose varies with the character of the water to be treated. The modern plants which have been installed in Ohio provide periods ranging from three to twelve hours in the coagulation basins.

The water containing a small portion of the floc next passes through the filters. These are generally constructed as rectangular concrete boxes. A 1,000,000-gallon per day unit will have an area of about 360 square feet. Large plants are laid out with units having a capacity of from 2,000,000 to 5,000,000 gallons. The bottom of the unit is covered with a strainer system over which is placed a layer of graded gravel which supports the sand layer with a thickness from 30 inches to 3 feet. The water is applied at the surface of the sand over which it stands to a depth of two to four feet. It passes downward at the rate of 16 feet per hour, which is equivalent to 2,880 gallons per square foot per day or 125,000,000 gallons per acre per day. The rate of passage of the water through the filter is of prime importance in securing proper efficiency. This rate is regulated and controlled by the use of apparatus which prevents excessive rates of filtration, still permitting the use of the head necessary for operation. The efficiency of the rapid sand filter depends largely upon the collection of the floc at the surface of the sand. This gelatinous substance forms a mesh through which the suspended matter and bacteria contained in the water cannot pass. The resultant effluent from the filter is therefore purified, clear and sparkling. After the filter has been in operation for a certain length of time, depending upon the condition of the applied water, it becomes clogged and will no longer pass the proper quantity of water without excessive loss of head. It is then necessary to wash the filter. This is accomplished by passing purified filtered water through the strainer system and upward through the sand at a velocity of vertical rise of 15 inches or more per minute, the overflow being carried from the filter box through a gutter and connection to the sewer. The washing requires about five minutes and in large plants entails a loss of water of about two per cent. of the water filtered.

Whatever method of filtration is used, the purified water must be stored in covered and watertight receptacles to protect it from secondary pollution. It is customary to construct a clear water reservoir adjacent to and as a portion of the filter plant, where the purified water may be stored before it is pumped into the mains. The size of these clear wells is dependent upon (1) the relation between the capacity of the filter plant and the daily consumption, (2) the period of pumping, and (3) the storage provided on the distributing system.

What Filtration Accomplishes.—The filtration of a public water supply accomplishes beneficial results which can be with difficulty measured. The apparent result, which is appreciated by the citizens of a community in general, is the greatly improved appearance of the water. Instead of a muddy and often foul liquid a clear and sparkling fluid is drawn from the tap. The ordinary operations of the household are facilitated and the people are generally well satisfied, whereas frequent complaints against the previous condition of the water had been received. The most important result of filtration of a public water supply is the improvement in health conditions. Normally it may be expected that the introduction of a filtration plant will accomplish a reduction of 75 per cent. in the mortality from typhoid fever. The reduction at Cincinnati has been over 90 per cent. and at Columbus over 80 per cent. Accompanied with the reduction in deaths from typhoid fever there is also a noticeable reduction in deaths from general causes. It has been universally observed that the reduction of typhoid fever immediately follows the installation of a filtration plant.

Of lesser importance than the benefit to public health the financial advantage resulting from the purification of a water supply receives some recognition. With a water supply of good appearance and of satisfactory quality the inhabitants of a city will use it universally. This will increase the income of the waterworks department and will in turn decrease the cost of furnishing water. Each individual who uses a purified water supply will derive a financial advantage over the use of a polluted and muddy water. The saving resulting from the improvement of the physical quality of the water is also important and will in time assist in paying for the treatment of the supply. It has been previously shown that the saving of lives by the reduction of typhoid fever is amply sufficient to pay for the cost of purifying the water. Considering the question from a financial aspect alone and without regard to humanitarian considerations, a city provided with a water supply of poor quality can ill afford to maintain it without improvement.

SOOKE LAKE WATER SUPPLY.

The engineering staff of the Sooke Lake waterworks project for Victoria (see *The Canadian Engineer*, July 23rd, 1914), reports that a length of 6 miles of the 10¼-mile steel pressure pipe line has been laid, and that the most difficult portion of the route has been dealt with. It is expected that the whole pressure main from Humback reservoir to Smith's Hill service reservoir in the city will be completed in January.

The reinforced concrete flow line, 27.3 miles in length, has been laid for a length of 14 miles, or over half its distance. By the end of the year it is expected that the contractors, The Pacific Lock Joint Pipe Co., will have another four or five miles in position. To date the rate of laying has averaged 3½ miles per month.

The tunnel work within the city limits has progressed very favorably, the third tunnel being practically completed.

REPAIRS TO RIDEAU CANAL.

The Deputy Minister of Railways and Canals has announced that improvements to the extent of $50,000 will be made by the government on the banks of the Rideau Canal. The canal will be unwatered at an early date for this purpose.

THE CONSTRUCTION OF DAMS.*

By A. E. Walden,
Chief Engineer, Baltimore County, Water and Electric Co.

THERE are many things to be considered in designing dams, and especially one of the commonly called "gravity type," or, rather, of the solid masonry type, which will be here called the mass type; the gravity type will be that as constructed by Beardsley and Ambursen and Ransome.

In making examination of a dam site, test pits or borings should be made for a good distance above the dam site to determine the composition of the soil or strata under the dam, the trend of the stream, if on rock, noting if these are at right angles to the stream or with the stream, and if the stone is subject to water holes; also the character of the ledge, whether seamy or not, and if it shows rapid disintegration where exposed to the atmosphere, and if under water, that it is easily worn away by the action of the water, as in some limestones.

In some cases it will be found that in the bed of the river there are two classes of stone, one portion of which is soft and the other hard.

A careful examination of the banks should be made for suitable abutments and abutment foundations, and the quality of the soil composing them; also the slope of the underlying rocks, so that steps may be taken to prevent seepage through and eventually a washout.

There are several ways that have been employed by engineers in determining the proper length of crest, all of which are more or less efficient when properly applied,

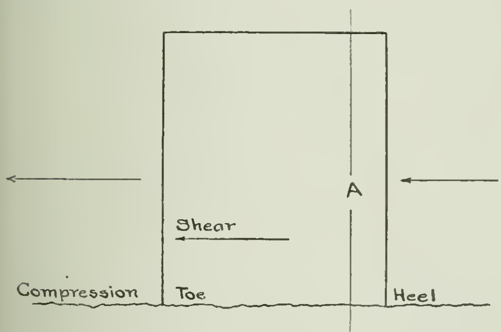


Fig. 1.

as are also certain empirical rules, where run-off data cannot be obtained, such as basing the run-off on a certain number of feet per second per square mile, certain instances of which will be given here.

In one case that came to the writer's notice the dam was constructed on a basis of three feet of crest per square mile of area which is hilly and steep, based on a rule that there should be on normal conditions at least one foot of spillway length for each square mile of drainage area, and this multiplied by three can take care of flood conditions. This dam failed many times, causing great property damage, but was finally constructed so that the spillway section would have a crest equal to taking the run-off at 20 cu. ft. per sq. mile at a velocity of one foot, and dividing this result by an assumed depth at the crest, considering it as a rectangular section, no allowance being made for the well-known weir action and of velocity of approach over such a crest. No trouble has since been experienced. This determination was made after an examination of the stream's banks for height of water, its depth at this point as compared with the width and depth of water at other points and for several hundred feet above and below; also noting the heights to which débris had landed; from information given by people living along the stream as to flood heights; from the drainage area and from rainfall data which had before for some

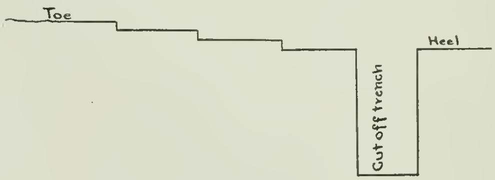


Fig. 2.

reason given results too small, to some extent probably due to the character of the drainage area, its topography, and the condition of the soil at certain times.

With 20 cu. ft. at a velocity of one foot per second and the banks 5 ft. high, it was assumed that the water reached 5 ft., but with 20 cu. ft. used as a basis and the dam lengthened to 146 ft., and estimating a crest depth under these conditions of 3 to 4 ft., this stream has since been measured for surface velocity during high water and an average velocity, on the surface, of 10 ft. per second obtained, with a depth of 20 in. at a point far back of the crest so that the increased velocity of the water at the crest of the dam did not affect it. Undoubtedly the velocity of the water varied at various depths, but this could not be obtained.

Assuming the average velocity at 10 ft. per second, and a sectional area of 146 ft. by 20 in., the approximate discharge per square mile in this case was 99 cu. ft. per second, and the greatest depth of water so far noted on the crest of this dam has been 3 ft. It is possible under these conditions that the velocity was from 15 to 20 ft. per second, but this could not be measured at the time, on account of lack of preparation.

In another case a dam was constructed for a crest depth of 5 ft. for a drainage area of about 300 sq. miles. This dam was 200 ft. long at the spillway, with about 1,000 ft. of earthen embankment about 18 ft. higher than the spillway section. The 5 ft. depth at the crest has been exceeded many times, and the gauge has shown a depth of 11½ ft. on the crest, which was beyond data based upon the government report's gauge readings at that time, and would be about on the approximate basis of 7 cu. ft. per second per sq. mile.

From an examination of many streams, watersheds, and dams, it would seem that one may expect to find that the run-off will vary from 50 to 100 ft. or more per second, and in some cases it has been considerably more than the maximum amount noted for a hilly section, that will give a quicker crest rise than a flat section will do, owing to the fact that the water cannot spread over any large area.

It may be assumed that a certain portion of the flood reaches the crest in the first hour, a certain portion in the second hour, and so on to five or six hours, or more, but this cannot be accurately determined beforehand with the data we have to-day.

Every effort should be made to obtain data from other dams on the same watershed, if any, or on similar water-

*From a paper read before the New England Waterworks Association, September, 1914.

sheds in the vicinity, as to the rise in a given length of time after a heavy rainfall, so as to determine the lapse of time between either the beginning or the maximum rainfall and the maximum crest rise. Rainfall data show that a maximum rainfall of 4 in. in one hour may be looked for, and from 8 in. to 10 in. in twenty-four hours. On this basis there would fall for each square mile in the first hour, 9,288,800 cu. ft. (1 in. equals 2,322,200 cu. ft.). Then the question would arise as to what part of

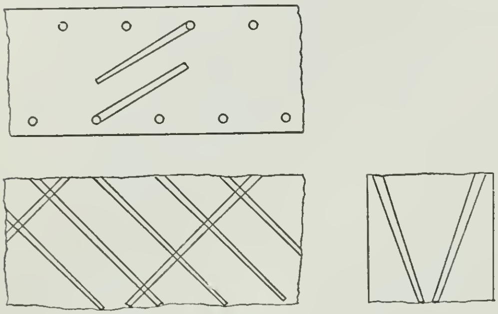


Fig. 3.—Method of Drilling.

this reaches the dam the first hour, and each succeeding hour until the maximum crest height is reached, and the effect the condition of the soil and the ground water content has on this. From J. B. Francis' records, the indication would seem to be that a depth of rainfall varying from 6 in. to 11 in. or more, with rates about as follows, may be looked for: 4 in. in two hours, 6 in. in about twenty hours, and 9 in. to 10 in. in thirty hours, etc.

For the rainfall and flood conditions, Fanning's formula has been much used, as well as others, but must be applied with care for the particular location, the period of the year in which the rainfall occurs, as on frozen ground or with a light fluffy snowfall it requires 15 in. or 20 in. to equal 1 in. of rainfall. While assuming 4 in. to 5 in. of wet soggy snow to equal 1 in. of rainfall, the rainfall combined with the water from the melting snow with the frozen ground underneath will give quite sudden changes in the flood conditions, which will exceed any rainfall obtained from hourly rainfall records; recording gauges at dam, however, would show this.

The effect of impoundings or pondage in reducing flood conditions, if the area is sufficient, where there is one or more dams above the one to be designed, should be considered. The crest of the dam under design should be proportioned to care for the failure of at least one, or more, of these dams in addition to that of flood conditions, depending on the location of towns and villages below, and the property value and loss of life likely to occur in case of such failure.

In the design of a dam of the mass or solid section type, as shown by section, Fig. 1, the dam may be considered as a beam fixed at one end and having an uniform load, and as such may have shear at the joints, tension in the upper face and at the heel, with compression at the toes, etc.

Then to care for tension in the upper face, steel may be provided, but its calculation would be to some extent theoretical. In any event, if securely anchored to the rock formation in drilled holes, and the steel provided with split ends and wedges, and afterward grouted in carefully, this method would certainly add to the stability of the dam, especially when the dimensions were properly proportioned to care for shear. Steel bars may be embedded at an angle of about 30 degrees, as shown in Fig. 4, or some other angle, with the horizontal so that the steel will take tension as far as it is possible to make it do so under these conditions.

In preparing the foundation, care must be taken to remove surface rock that has deteriorated, to a depth that test holes show to be safe, and then the surface under the dam should be roughed, either toothed or sawtoothed, or in a similar fashion, so that pressure will tend to force the dam downstream and against the toothed or roughed surface, as shown.

This work should be carefully performed, either by the use of dynamite or steel points and wedges. But dynamite should be used in the hands of an experienced man, who understands placing shots. Especially is this true of the cut-off wall at the heel, for if such placing is done it should be carried out in the manner described.

Care should be taken to so set the upper drill holes to line for a narrower cut than is required, then removing the shattered stone by wedges and points, as it is necessary that the cut-off wall should not be shaken to such an extent that there will be liability of leakage to the downstream side.

A careful note should be taken to see if seams run at right angles with the stream, or partially with the stream; also the character of the stone and of any change in the composition, as there are cases where there are one or two different rock formations in the same river bed.

One or two test holes should be exploded with various charges, at some other point, to determine the proper charge to be used, but vertical holes should not be used, unless absolutely necessary. In this respect it might be said also that a regular 500-volt current will explode twenty holes, and such a number of holes exploded simultaneously will do better work than three or four holes ex-

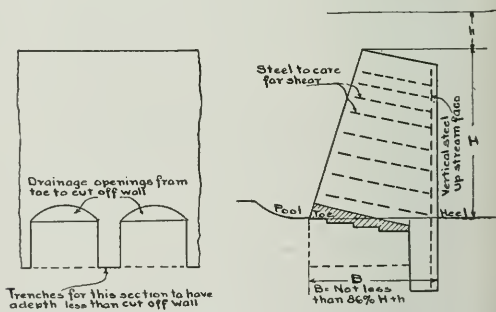


Fig. 4.—Solution of Solid Dam Showing How the Arch Can be Used for Drainage from Cut-off Wall to the Toe.

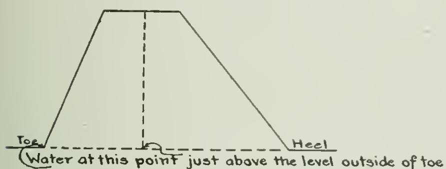
ploded at a time. Holes may be placed as described below:—

Holes running with trench on each side, about 4 ft. apart and at an angle of 45 degrees, with extra holes at each end at same angle, looking the other way. The depth of these holes will depend on the depth of trench required and the width of the same. In addition to this, holes may be drilled from side to centre as shown in the end section, Fig. 3.

The writer has seen trenches cut in this manner, by men who understood tunneling and channeling, that would meet the conditions required in every respect.

Test holes should be drilled to sufficient depths, 10 to 20 ft., more or less, to be sure that no seams or underlying strata of clay underly the rock, and tested with compressed air or water to at least 100 lb. pressure, and pressure maintained for such a time as will surely determine the condition in these test holes. Shale formations are liable to large seams; overlying strata of clay and limestone formations to water channels or recesses. The holes should be drilled from 10 to 15 ft. apart, more or less, depending on the conditions found to exist.

There seems to be no reason why solid section dams should not be constructed in the form of arches that extend from the toe to the cut-off wall, and the spaces under these arches would effectually care for any uplift due to water seeping through or under the dam, supports to the arches, or haunches of the arches, of course, being carried sufficiently below the surface to effectually protect them from wash and undermining, and would be more satisfactory than large pipe placed 8 to 10 ft. apart, more or less. Or 10-in. split tile may be employed for this purpose, which would be more satisfactory than a solid tile, but in any event should be covered with loose stone so as to allow free access to the tile from all sides.



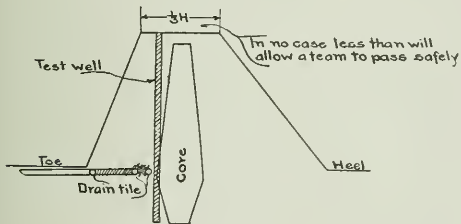


Fig. 5.

There is another condition that must be given consideration in this work, and that is, at the toe of the dam there will usually be found a pool cut out in the rock or other surface, that at or near the centre of the spillway section will have a depth of from one-third to one-fourth of the height of the dam; and it will be found that if this pool is filled with concrete, it will eventually wear to this same depth and there remain about stationary. It would seem to be good policy to retain these pools, unless some other method were taken to care for the action of the water at this point. Some types of dams would probably be less affected than others.

The solid dam may be reinforced and tied to bedrock in the cut-off portion, as described before and as shown here, and thus would take tension in the upstream face of the dam, in addition to which the diagonal bars at some angle would tend to take the tension due to sheer and prevent any tendency to sheer in the horizontal plane, or where new work was tied to old, in case that the joint was not properly cleaned.

The trenches for the haunches for the supports of the arches should have a depth at least equal to the pool and the cut-off wall, preferably somewhat below this. These arches should extend back to the cut-off wall, which should be made sufficiently strong for the purpose, and will give a more efficient drainage than it will be possible to obtain with pipes of any kind.

Referring to the earthen embankment as employed at the abutment ends of some dams, the following construction was employed by the writer, and tests carried on every day for several years to see if there was any increase of the water in the test well (Fig. 5) but no increase was found.

Again, from the core out to the toe every 20 ft., double lines of porous drainage tile were laid from the double line of tile that skirts the core to the double line that skirts the embankment just under the toe and to the outside of the embankment to some suitable disposal plant that would allow of the amount of water running to waste to be measured, from time to time, these drains being covered in turn with crushed stone to a depth of 6 in.; the reason for this being that the writer excavated on one such embankment to the centre of the same, the embankment being composed of a gravelly soil, and found no water until the centre of the embankment, or core, was reached, showing that the drainage kept the embankment dry from a point above the centre to the outside.

As before stated, the surface or foundation on which the dam or embankment is to be constructed should be excavated either in trenches or as shown, as this gives the foundation a greater frictional or sheering resistance.

Table I. gives data on dams, the depth and velocities of waters at the crest for which these were designed; and the actual depth obtained will give an indication of the conditions as they actually exist.

TABLE I.

1	4,185	8.5	9	16.5	1,000	50
2	4,475	8.5	13.5	14.4	1,000	50
3	3,085	...	16.4	18	1,000	..
4	1,545	8	8	9.5	890	60
5	7,000	...	6	....	318	..
6	19,600	...	12 and 5	....	1,500	..
7	66,000	...	12	10	700	..
8	1,380	...	7	2.2	400	..
9	5,760	...	15	12	1,078	..
10	400	...	5	3.6	120	..
11	3,560	...	(Could stand 9; stand flood of 50,000 sec. ft.)	4.4	1,108	..
12	15,800	...	15	....	480	..
13	16,600	...	15	....	500	..
14	1,270	...	5.5	8	260	..
15	.....	...	...	....	....	..
16	26,766	...	17.5	....	2,350	..
17	300	...	5	11	200	..
18	320	...	5	8	119	..

Dam No. 18 was designed to care for 4,400 sec. ft.; had a total crest length of 450 ft. and a spillway section of about 120 ft., and under flood conditions water rose 8 ft. above spillway section and 3 ft. over the crest, the estimated discharge being 14,500 sec. ft.

There is one other point in the case of gravity dams (Fig. 6) in that the factor of safety of 4 for deck loads has been used, but consideration should be given the following sketch (Fig. 6), also the cost of such work. It is manifestly certain that no load will ever be obtained that would stress the deck to call for a factor of 4, or even a factor of 2, and that a factor of $2H$ would be amply safe even for ice, as with a sloping deck such a factor would protect it from floating blocks or a plane of solid

ice, as the blow would be glancing; and again, the silt which fills in on the deck would act as a cushion. Then again, floating objects are most apparent at flood when the water on the crest is deepest, which would tend to carry these floating objects safely over the crest. And in any event, the stress in the material would not exceed the normal load stress effect. It may be said that load stress is uncertain. This may be true of some dams.

Now, the writer is not advocating a construction that would be unsafe under any consideration, but that more careful consideration be given these conditions on account of cost in a safety factor for loads that would be both safe and economical in so far as the cost of material and construction were concerned, but without going to extremes for a condition that will never be reached.

Records should be kept of the depths of the waters on the crest of the dams at all times, and the cost of an efficient instrument for this purpose is small. Such records, together with the records for rainfall, depth of

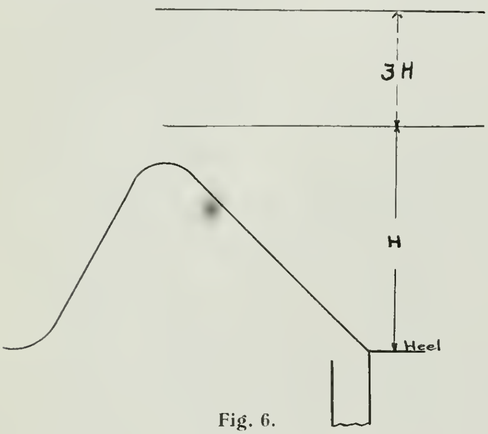


Fig. 6.

rise on the crest of the dam and the time relative to the maximum rainfall, would give data that would be invaluable, in a short time.

Records should also be kept of the soil strata through which excavations for test pipes and test holes pass.

The question of frost at times may have to be considered.

Every available record should be used to determine the run-off from the rainfall on a given watershed, as the run-off and the time of the maximum run-off are affected by so many conditions that there should be as few guesses as possible, and even the records should have a reasonable percentage added.

IMPROVEMENT WORK IN VANCOUVER.

The following is a summary of the street work during the past year in the city of Vancouver, according to a recent report of Mr. F. L. Fellowes, City Engineer. The various works are given in miles:—Pavements, 6.98; concrete sidewalks, 8.78; curbs and gutters, 1.44; curbs, 2.54; gutters, 4.41; clearing and rough grading streets, 11.79; clearing and rough grading lanes, 8.93; clearing and rough grading boulevards, 0.33; grading streets, 20.65; grading lanes, 3.26; grading boulevards, 11.89; rocking streets, 12.24; rocking lanes, 4.45; planking streets, 16.19; planking lanes, 5.87; three-plank walks, 18.03; sanding and oiling streets, 46.88.

BLAST FURNACE SLAG IN CONCRETE.

WITH the rapid growth of concrete construction, the advantage of blast furnace slag as an aggregate in reducing the dead weight has made a strong appeal to many engineers. The result has been that the building codes of several large cities have permitted the use of furnace slag equally with any other material ordinarily used for aggregate. An extended series of tests involving the manufacture of five hundred 6-in. cubes, 100 of these to be crushed at each of the several periods, 28 days, 3 months, 6 months, 9 months and one year, has been recently undertaken. Commenting upon these tests the Iron Trade Review states that as the work progressed, results were such that the number of cubes tested at the 9-month and one-year periods was reduced to 50 each, and it is proposed to crush the remaining 100 cubes at 6-month intervals up to 6 years, 10 cubes at each period. The materials used in the test were all produced commercially, and the work of making the specimens was no better than under ordinary field conditions of construction. Thorough mixing was assured, the work being done by hand.

The cement used was standard Lehigh Valley brand, complying with the standard specifications of the American Society for Testing Materials. The sand used was Jersey gravel. This is not an ideal gravel, but was used because it was the material of the market. The coarse aggregate commercially called three-quarter-inch material all passed the 1¼-in. sieve and were retained on the 1½-in. sieve. All material was in the proportions one part cement, two parts sand and four parts coarse aggregate. The concrete was mixed to the ordinary work consistency, rather wet than dry. The cubes were air stored in a dry cellar, being sprinkled with water once a week. The average compressive strength in pounds per square inch for the various tests are as follows: 28 days, 1,561 lb.; 3 months, 1,952 lb.; 6 months, 2,589 lb.; 9 months, 2,841 lb.; 1 year, 2,797 lb. A study of the test results shows that while at 28 days, 3 months and 6 months, if the number of individual tests fail to agree closely with the general average, the large percentage show considerable greater strength than the general average. A similar study of results at 9 months and one year shows that of the results not in close agreement that the general average, a somewhat larger percentage falls below this general average than runs above it. However, as the results which are above the general average are much more above the average than the low results are below, it may be assumed that the average results are conservative. This is more evident when it is considered that the sand used was not what could be considered as first-class material. Also, the comparatively small size of the slag aggregate must have lowered the strength of the concrete.

The findings seem to point that slag may be employed as an aggregate in competition with broken stone or gravel, since the crushing strength of broken stone or gravel concrete, made under ordinary field conditions, will not generally average much over 1,500 lb. per sq. in. at the age of 30 days. From the actual strength of the concrete developed in these tests, its weight per cubic foot, the recognized solubility of slag which permits it to act as a puzzolanic material, its alkaline nature which is especially conducive to rust-proof in the case of reinforced concrete, and from the relatively high combined percentages of silica, alumina and iron, which make for permanency of the resulting concrete, the conclusion is that slag is satisfactory for use as an aggregate in concrete.

ROAD ECONOMICS.*

By J. E. Pennybacker,
Chief of Road Economics, U. S. Office of Public Roads.

ROAD economics may be defined as that branch of economic science which treats of the cost and use of a road as a public utility. Cost and public utility, in a comprehensive interpretation, are the determining factors with reference to the amount of money to be expended, the method of its procurement, the liquidation of any indebtedness incurred in connection therewith, the location of the improvement, the character of the work, economy in the management of the project, and the utilization of the completed road for the economic benefit of the public.

The subject is logically comprised in two divisions, the first of which deals with those larger questions of legislation, finance, organization, road classification or selection, the utilization of collateral agencies, and the management of the road as a completed project. The second division of the subject, although more limited in scope than the first division, is important from the standpoint of economy and efficiency, as it relates to the various activities in connection with the actual work of construction. Examples under this division would be the lowering of cost by the intelligent use of labor-saving machinery; the keeping of adequate and efficient cost records so as to detect extravagance, incompetence or dishonesty; the systematic purchase of materials, and the use of such other measures as would serve to produce a satisfactory road at the lowest practicable outlay.

Legislation, to be effective, must be economically sound, and it is necessary to the intelligent framing of road laws that the economic considerations applicable to the subject should be known and accepted by the legislators. A system of financing road improvement is largely the outcome of legislation, but is often modified by the exercise of administrative discretion. Organization, like finance, is to a great extent prescribed by statute, but here again the personal equation enters largely in the determination of efficiency or inefficiency. The utilization of collateral facilities of the state, such as convict labor and the aid of state institutions for investigative and educational work is largely determined by law, but here again administrative discretion and the personal equation play an important part. The classification and selection of roads for improvement, although resting upon legislative enactment, are much more largely an administrative question that those to which I have already referred, and the same holds true with reference to the use of the road after completion so as to best serve its purpose as a public utility.

It is thus evident that these basic factors should be correlated and that the undertaking as a whole should conform to those economic considerations which may be regarded as fundamentally sound. I have, therefore, formulated ten fundamental propositions which I hold to be incontrovertible and so self-evident as to be axiomatic. I shall, therefore, first submit these ten axiomatic propositions, and then endeavor to explain to you their practical application.

1. That all who share in the benefits of road improvement should share proportionately in the burdens.

2. That the degree of improvement should be proportionate to the traffic importance of the road improved.

3. That the rate of payment or the rate of accumulation of the sinking fund on any public debt contracted for road improvement should approximately equal the deterioration of the improvement.

4. That road building and maintenance comprise work requiring special qualifications on the part of those who direct it.

5. That responsibilities should be definite as to persons.

6. That continuous employment is more conducive to efficient service than intermittent and temporary employment.

7. That the specialists who direct road work should be appointed instead of elected; and that they should hold office during efficiency instead of for a fixed term.

8. That no road is wholly permanent and that it requires continuous upkeep, for which financial and supervisory provisions must be made.

9. That cash is a much more satisfactory form of tax than is labor.

10. That all agencies at the disposal of the state, capable of use in works of public improvement, should be so used, rather than in such commercial production as would conflict with private enterprises.

The practical application of these ten axiomatic propositions does not involve intricate or impracticable procedure. Under the first proposition, that burdens and benefits should be shared proportionately, I would call attention to the fact that the country road is no longer a mere local utility. The product of the farm is absolutely essential to the existence of the city population, while, conversely, the product of the city factories finds its way to the most remote country districts. There is an interdependence which should carry with it a co-operative sharing of the burdens incident to improving the facilities of transportation between country and city. Legislation should, therefore, be framed so as to provide for city taxation in aid of country road improvement. Automobile owners should individually pay a material portion of the cost of our public roads, and they are already cheerfully doing so in many of the states. Last year the state revenues derived from automobiles amounted to about eight million dollars applicable to roads, out of a total from all sources, state and local, of about $205,000,000. The exact method of apportioning the road taxes is a detail which can readily be worked out by each individual state.

The second proposition, which calls for the improvement of roads in proportion to their traffic importance, strikes at the very root of our present method of apportioning road improvement. Too often have we seen examples of costly improvements distributed according to the dictates of a few influential citizens or according to some arbitrary arrangement of political units or for sentimental reasons, or through a cheerful, haphazard indifference. It is now generally believed that four-fifths of the traffic of this country is carried on one-fifth of the road mileage. It should be manifest that the most heavily traveled roads should first receive attention and should be improved in the most substantial manner. It is entirely feasible to make an expert study of a county road system and indicate graphically the traffic areas for each important road, much as you would show drainage areas for waterways. The yield and the probable traffic in ton miles for these traffic areas can be readily determined so as to establish with reasonable exactness the amount of outlay which the traffic would justify. The relative cost of such a determination would be almost negligible if in-

*Paper read at the Fourth American Road Congress, Atlanta, Georgia, November 9-14, 1914.

curred as a preliminary to a large outlay for actual construction.

The third proposition, that debts should be liquidated in proportion to the deterioration of the road, is intended to prevent the incurring of a debt which will outlive the utility which it was designed to create. There are two extremes in the controversy which rages over this question of public debt. There is the one faction which either opposes debt in any degree, or contends for an indebtedness of such short term as to make it almost a cash transaction, and asserts that the road is entirely destroyed long before the debt becomes due. The other extreme faction contends for long-term indebtedness, on the theory that as posterity will reap the benefits it should bear the burdens, and that a road well maintained never wears out. As a matter of fact, location, if intelligently made, should be permanent; likewise all reduction of grades. The drainage features, if honestly and efficiently constructed, should be reasonably permanent. The road, except under extraordinary conditions, should, therefore, be considered reasonably permanent as to these features. As a general rule, the foundation of a road should not require renewal if the road is subjected to adequate and continuous maintenance. Avoiding any detailed consideration of the exact proportion of the total cost of a road represented by these features, I should say that in general the permanent features would average at least 50% of the total cost. So that, if the other 50% must be figured as perishable and subject to renewal, the debt should not cover a period longer than twice the length of this perishable portion. For example, if a macadam road is constructed at a cost of $6,000 per mile and has an estimated life of ten years, the bonds could run twenty years, because, at the end of ten years the depreciation is $3,000 and the actual value is $3,000. Another expenditure of $3,000 is made and at the end of twenty years when the bonds become due, there has been a total outlay of $9,000, against which should be credited the permanent value of the road at $3,000, making the net outlay $6,000, or the face amount of the bonds. This is merely an example and a generalization. It would be desirable to ascertain the permanent and perishable portions in each undertaking.

The fourth proposition, which calls for the employment of specialists in road work, is so nearly self-evident in its application as to require very little explanation. I should say, however, that if the laws of the state would require that all persons selected to have immediate direction of road or bridge construction and maintenance must possess practical knowledge and experience, and if this fitness should be tested by some sort of competitive examination to be prescribed by a state highway department, acting either directly or through a civil service commission, the net result would undoubtedly be the saving of many millions of dollars of road revenue and a wonderfully increased efficiency in our road system.

The fifth proposition, that responsibilities should be definite as to persons, is aimed at the elimination of our present complex and cumbersome system of road management. If all of this antiquated organization could be swept aside and in its stead one or a few officials endowed with authority and charged with responsibility in each county, the beneficial effects could not fail to be most marked. If the people, individually or in a representative capacity, could immediately place their finger, so to speak, upon the man responsible for the discharge of public duties we should have no more political juggling and the passing of responsibilities and duties onward in an endless chain.

The sixth proposition, that continuous employment is more conducive to efficiency than temporary employment, finds its antithesis in our present annual or semi-annual junket which we call "working the roads." It is so self-evident that a minor defect in a road can be repaired at its inception with little effort, and that if allowed to go on it may require the entire reconstruction of the road surface, that is seems scarcely necessary to urge the soundness of this proposition. If a small force of laborers with necessary tools and teams were employed throughout the year on the roads it would not cost any more money than to call out a small-sized army of road hands twice a year, and would not only result in quick repairs where needed but would also insure that the most work would be done at the places where it was most needed. The force would be small, mobile, trained, interested, subject to effective discipline and altogether infinitely more efficient than the unwieldly forces now employed.

The seventh proposition, which calls for appointmen rather than election and for the holding of office during efficiency instead of for fixed terms, is designed to attract to the work men who look upon road-building as a life profession or occupation. A good engineer may be a very poor politician and a good politician may be a very poor engineer, but in a contest in which votes are essential the good politician will usually defeat the good engineer, although the position requires engineering ability rather than political ability. Do not spoil a good highway engineer or superintendent by making him cater to the popular fancy. If he is the right man in the right place, it is absurd to limit him to a fixed term, for his position is not a reward. The county is purchasing his services and is supposed to get value received, and it should continue to purchase so long as he delivers the goods.

The eighth proposition, that no road is wholly permanent and that it requires continuous upkeep, is intended to impress upon legislators and administrative officials the necessity for making adequate financial provision to care for roads, no matter how costly or efficient their construction. A house is not permanent without repair, a railroad track is not permanent without repair, then why should public funds in a large amount be expended in road construction which, without adequate maintenance, may deteriorate to the extent of 50% in a few years? It would seem almost a reflection upon your intelligence that I should urge upon you these conclusions which are so generally understood and accepted, were it not for the fact that their acceptance is very largely in theory and not in actual practice.

The ninth proposition, that cash is a much more satisfactory form of tax than labor, is put forward as a protest against the continued cherishing that old heirloom known as "statute labor." If A owes B $10 and B has the option of collecting that $10 in cash or taking the amount out in labor which A shall select and which is totally unfamiliar with the character of work which B requires and which would be semi-independent of any control by B, we should consider it very unsound business judgment if B were to accept the payment in labor instead of cash. If you provide an efficient highway engineer or county superintendent with a modest amount of cash and let him select competent, efficient laborers, he can quadruple the effective results obtained by the same number of laborers under the old statute system. I know that there are sections of country where it is almost impossible to collect a cash tax. A certain amount of discretion might in such cases be entrusted to the county authorities to accept payment in labor.

The tenth proposition, that state agencies which may be used in works of public improvement should be so used instead of in commercial undertakings, is directed partially toward the convict labor question, and is based

upon the assumption that offenders against society owe a debt to society which should be paid in such form as will most benefit society, and the further assumption that honest labor should not be discriminated against through the sale or disposal of products created by criminal labor. The practical application of this proposition would mean the employment of convicts in road-building, the preparation of road materials, or in other works of public improvement so far as practicable. This proposition is intended also to emphasize the necessity for correlation of the states' various agencies in the interest of road improvement. For example, a state geologist should be helpful in the selection and location of road materials, the laboratories of state universities should be useful in the testing of materials, the university staff should be helpful in the givng of theoretical instruction and in many cases in practical extension work, state bureaus of statistics and agriculture should be helpful in accumulating essential data for the road improvement work in the state, and state civil service commissions should be of very great use in the inauguration and conduct of the merit system in the filling of positions requiring technical or practical qualifications and experience.

PROPOSED CAR LINE EXTENSIONS FOR TORONTO.

Four by-laws providing for the expenditure of $500,000 for transportation utilities are likely to be presented to Toronto ratepayers on January 1st. The works and expenditures involved are as follows:—

(1) Construction of civic car line on Lansdowne Avenue from St. Clair Avenue southerly to connect with the northern terminal of the Toronto Street Railway line on that street at a cost of $105,000.

(2) Construction of a double track civic car line to serve North Toronto, commencing at or near Yonge Street and Shaftesbury Avenue, easterly across the Reservoir Park ravine parallel to the C.P.R. tracks, northerly on a proposed street to the corner of Rosehill and Clifton Road, north on Clifton Road and Erie Street through Mount Pleasant Cemetery, on Alberta Avenue and Mount Pleasant Road to near Broadway Avenue at a cost of $320,000. The above definition of the route has not been definitely settled upon by the works commissioner and will probably be subjected to one or two minor changes. Before work on the line could commence the works commissioner has thousands of dollars of sewer work to lay on the proposed route and a road to construct through Mount Pleasant Cemetery. This road is to be permanent and must be sewered the whole length before the roadway can be constructed.

(3) Proposal to purchase all the tracks of the York Radial Railway from Queen Street within the city limits at a cost of $52,000. The company's franchise on this portion of the line ran out last year.

(4) A proposal to purchase $100,000 worth of motor buses to establish services at unspecified sections in the city.

M. Beatty and Sons, Limited, Welland, Ont., announce that they have opened a district office in Toronto with address 154 Simcoe Street, where they are represented by Mr. K. M. McKee, formerly of the head office. Previously this company has been represented in Toronto by H. W. Petrie, Limited.

ADMINISTRATION OF WATER RIGHTS IN BRITISH COLUMBIA.

By William Young,
Comptroller of Water Rights.

THE history of water administration of British Columbia for the past 50 years may be said to be the history of water administration of several of the Western States of the Union south of the International Boundary. From the time when the province became a Crown colony the ownership of the waters in the rivers and streams has been vested in the Crown, and in the circumstances, water rights were granted through a period of well over forty years, unfortunately in those early days in an unmethodical manner. The result is that there are streams that have been over-recorded many times, and again, many of these records are a hundredfold in excess of the requirements for which they were taken out. Although throughout these years there was a water law that provided for granting of rights, such law contained no machinery for administration afterwards. With this weakness in the law and the fact that records were granted by government agents in different sections without reference to a central authority, the final condition became one of chaos. Just as some of the states to the south have faced a similar condition and set things in order, so have we had to set about this work, a beginning being made in 1909 when steps were taken to terminate the growing confusion; but no organized effort was made until the summer of 1912, when the Hon. Mr. W. R. Ross called in able advisors to formulate a system and advise the best method of undertaking the work.

There is now nothing new to present in the administration of water rights in British Columbia. In taking up the many problems that confronted us we went about it in the same manner that the trained scientist undertakes some new field of research. An effort was made to ascertain what had been done in other countries. While amendments to the Water Act were made in 1913, the results of organized expert effort may be said to have crystalized in the amended act of 1914. We do not claim that this act as it now stands is perfect, far from it; for during the preparation of amendment of the act complete organization of office and staff has been well advanced, current work taken care of, an order of work established and the problem of handling the large quantity of work in arrears commenced. As regards investigating the work that other countries have done, it may be said that we have just entered on the border of a vast realm; for of all applied sciences irrigation may be said to be the oldest, not to say anything of water power or waterworks.

The foundation of our administration of water rights is our water law. What follows hereinafter is a brief analysis of this law, an outline of our order of work, and a few remarks with respect to administrative problems and of how the administrative staff deal with the work.

The basic principle of our water law is set out at the beginning in the declaration that all the unrecorded water in any stream is vested in the Crown in the right of the province. The purposes for which water rights may be acquired are there given. Organization and administration are next taken care of. Procedure in the acquirement of water rights follows, then the organization of communities, associations and municipalities, and lastly the Board of Investigation, its functions and procedure.

Under the chapter "Organization and Administration," the law briefly authorizes the appointment of the

comptroller of water rights, and the Board of Investigation, each with specific powers; the appointment of district engineers, also with specific powers; the division of the province into water districts and the appointment of water recorders. The law then sets out the administrative duties and powers of the minister, also those of the Lieutenant-Governor-in-Council. With respect to the latter, one of the most important powers is the making rules and regulations for the carrying out of the spirit, intent and meaning of the law. With this basis to work on, the organization is elaborated.

The comptroller of water rights issues all licenses and administers the act in accordance with the rules and regulations in their application to the various purposes in which water may be used. He is also empowered, with the approval of the minister, to carry on such topographic or hydrographic surveys and other engineering investigations as may be in the public interest. The Board of Investigation was formed for the purpose of hearing claims, determining old rights and adjudicating thereon. The Lieutenant-Governor-in-Council or minister may, however, refer any matter, question or thing to the board for the purpose of obtaining information or making any enquiry thereon. As constituted, the board normally consists of three members, two of whom shall form a quorum. The comptroller of water rights is a member of the board in all matters excepting those pertaining to old records.

The division of the province into water districts is in the interest of efficient administration and the engineers appointed to supervise such districts have stated powers to enable them to enforce "beneficial use" of water and settle disputes; in other words, the district engineers represent and are deputies for the comptroller of water rights. The water recorders, usually the government agents, act as representatives to the comptroller to the extent of receiving applications for water rights, such applications are advertised and then filed with him, so that the neighbors of the applicant may have an opportunity of ascertaining if their interests are affected. The rules and regulations deal particularly with petitions, surveys, plans, fees and rules covering the use of water rights.

It is not the intention at this time to enter into any description of how water rights may be acquired for the reason that there is a marked similarity to the procedure that obtains in many of the water laws of other parts of North America. Suffice it to say, however, that the procedure is now simplified in the interest of the settler so that it is no longer necessary for him to call in a lawyer. Already this feature has proven a boon to many a pre-emptor or small owner to whom a lawyer's fee would be a charge he could ill afford.

The purposes for which water rights may be acquired are fourteen in number and, although they are all important, three great purposes stand out with prominence:

(1) Irrigation, whether by individual, community, company or municipality;
(2) Power;
(3) Waterworks.

A broad distinction in purpose may be said to exist: "Purposes that affect the public interest" and "purposes that affect the individual." Around these groups our administrative machinery may be said to be constructed and in their light the department is in a process of organization for effective and efficient administration.

The creation of the organization we now have may be said to date from 1910, when the administration was centralized in Victoria. During 1911 and 1912 considerable progress was made in the creation of a system adapted to the business of administration, in expert investigation of conditions, and in formulating an order of work. 1913 witnessed the division of the province into water districts, the opening of branch offices and the appointment of district engineers; also a united effort in the preparation of rules and regulations for the administration of the act, and important amendments to the act, among which may be mentioned a chapter dealing with irrigation, whether by community, company or municipality. Very important amendments to the Railway Belt Water Act were also made, whereby the administration of water rights in the railway belt finally passed from the Dominion to the province, and as an outcome of this the British Columbia Hydrographic Survey was organized for systematic work throughout the province.

The effective work of administration may be said to have begun in this year, and that there might be uniformity of effort, the order of work referred to as having been adopted in 1912 was slightly revised to meet the conditions. This order is as follows:

1. Investigation of old records.
2. Systematic and continuous work in stream gauging.
3. Study of the proper duty of water.
4. The prevention of wasteful use of water.
5. Policing of streams.
6. Economic distribution and delivery of water.
7. Inspecting water systems to determine their efficiency and safety.
8. Determination of storage possibilities.
9. Investigation of water powers.
10. Investigation of source of domestic water supply.

This order of work involves the three great groups of purposes referred to, and which are, in each particular district, of greater or less importance.

Investigation of old records comes first, and necessarily so, for the very good reason that effective administration was quite impossible until the chaos of almost 50 years had been cleared up. Under these circumstances the efforts of our district engineers have been largely concentrated on engineering investigation of those records, although every line of work has been given more or less attention. There are about 8,000 of these old records, practically all of which have now been reported on. These preliminary reports have been of great value to the Board of Investigation. The hearings now held by the board are very different to those first held without such preliminary engineers' reports. The success resulting from the efforts of this tribunal during the past two seasons is as much due to these reports as to anything. Decisions on 2,000 records have been rendered, and to date but five appeals have been filed, two of which are now in default. We are hopeful this measure of success will continue. In some of the districts the board work is complete, and we are now fortunately in a position to follow more fully and carefully the various other lines of work, with results that have been most encouraging.

I have referred to three great purposes as being of public interest, *viz.*: Irrigation, water power and waterworks. Since the difficulties met with in administration centre around these, we will refer to them in due order.

The Administration of Water for Irrigation.—Prior to 1914 there was no provision in the law that would enable the officers to cope with the conditions that already existed, and under the circumstances their hands were practically tied. The Water Act of 1914, however, included new sections which involved basic principles and

made administration for irrigation possible and effective. These principles are:—

(1) "Limiting the quantity to beneficial use," that is to say the quantity of water used per acre shall be limited to such quantity as experience may from time to time indicate to be necessary for the production of crops in the exercise of good husbandry.

(2) "Rotation in use," when a number of water users may arrange a system of rotation that will best meet the requirements of growing crops and at the same time secure an economic use of the water.

(3) "Consideration of the particular crop grown," a provision which opens the way for adjustment that is in the interest of the community as a whole.

As to what kind of crops should be grown, I do not consider myself qualified to discuss such an important subject; but as regards these principles and their administration I am reminded of a statement credited to Sir William Wilcocks in reference to the control of use of water in the prevention of deterioration of land: "In this respect the government is autocratic and can and must enforce the regulations devised by its experienced advisors. It need not await the slow education of the great body of water users before adopting those practices which experience has shown are necessary for the general prosperity."

For the administration of these principles the powers of the district engineers were enlarged, and in carrying out "rotation in use" they may arrange when necessary for the appointment of water bailiffs whose duties are clearly set out in these sections and whose authority is backed up by the Police and Prisons Act. These principles and the provision for their enforcement are not new. In referring to the history of irrigation, particularly in countries where it has been practiced for centuries, we are told that the water that irrigates your field has to flow in a channel which passes the field of all your neighbors and cannot be maintained in a state of efficiency unless all do their duty, and it is easy to understand how method, order and obedience to a properly constituted authority very soon developed themselves. We are also told how autocracy was introduced into a free community of irrigators on small, independent canal systems and in times of difficulty the irrigators chose from among themselves a dictator for the whole period of scarcity of supply and his orders are obeyed and respected as though he were an absolute monarch, and further, that they invariably chose a good man."

In short, success here may be said to depend upon the human equation and we have kept in mind these facts of old-world practice in the appointment of bailiffs, insisting upon these men having the confidence and respect of the communities in which they reside. The result of the introduction of these principles in some districts where water feuds have existed for years has been most encouraging. Irrigators have again become friends and neighbors, realizing that their individual success and prosperity meant the prosperity of the community. In one particular instance where an order of rotation of water was instituted, as the water became scarce it was found that some of the prior record holders had ditches that absorbed all the water in the creek before it reached their land. As this state of affairs became obvious the bailiff eliminated these record-holders from the order of rotation in the use of the creek, and to the credit of these men it may be said that, although in other years they had caused trouble, they now acknowledged the justice of the bailiff's ruling, they could not make beneficial use of the water, and it was not in the interest of the community that they should prevent others from doing so.

Then there are other important features in the interest of irrigation that permit of effective administration and encourage organization that will mean not only development, but greater co-operation among farmers. These are:—

(1) The organization of water users communities;

(2) Organization of mutual water companies;

(3) Organization of public irrigation corporations, or irrigation municipalities.

Time will not permit of reference to these, other than to state that enterprise has been stimulated in different farming sections. Irrigation communities are being formed and the department have now under consideration a number of petitions for the formation of irrigation corporations in respect of which the preliminary engineering work is well advanced. It is expected that the various conditions required by the act as regards organization and management will be fulfilled during the coming winter, and that another year will see several irrigation corporations or municipalities in operation.

Administration of Water Rights in the Development of Power.—This purpose and its administrative requirements has received quite as much consideration as the purpose of irrigation. Recent amendments to the act in this respect were but few, but of great importance. It is no longer possible for a company to organize with the minimum of capital permitted by the Companies Act for the purpose of carrying out an undertaking requiring several millions of dollars. It is now impossible for a purely speculative element to secure and hold indefinitely a valuable franchise. The administration in this respect is largely governed by rules and regulations that the Lieutenant-Governor-in-Council may from time to time make for carrying out the spirit, intent, meaning and purpose of the act. In respect of power, these rules deal with surveys, construction, the operation period and fees. In regard to the companies now operating the determination of the fees to be charged is now occupying our attention. How such fees should be arrived at is clearly set out with an alternative; this alternative being that the fees may be based on a reasonable station output. For the present, we are taking this as the average daily horse-power arrived at from the total output in kilowatt hours at the power house switchboard. As the old records are eliminated and licenses substituted therefor and the organization for effective administration progresses, we shall in due course go more fully into the question of fees, basing such on the several factors set out in the rules rather than on the basis which has been adopted for the current year.

Hydro-electric power is essentially a specialty and to deal with it in a proper way, a section of our staff will, in due course, give its whole time to its administration and study.

The problem of water power administration and policy is one of economic importance and the question that confronts us is to what extent should the Crown become interested. On the one hand we have the example of the Hydro-Electric Commission of Ontario, the progress of which we must carefully follow, analyzing the reports and criticisms pro and con. Then there is, on the other hand, the necessity for encouraging investments of private capital, subject, however, to the principle that public utilities as natural monopolies must be under regulation by the Crown. What the ultimate result will be only the future can tell.

As the province must know something of its assets in water powers the work of stream investigation has been taken up. This work for the season now closing has been more especially in the Okanagan Valley and, comprises topographic work, and stream investigation for power, reservoir investigation, stream gauging already having been arranged for. Small powers are not overlooked. It is only necessary that data be made available in some instances to bring about development, as a small power may mean an important industry to some community.

Administration of Water Rights for the Purpose of Waterworks.—Administration in the issue of licenses and collection of annual fees is usually plain sailing in this purpose. There is, however, a phase of it that is of great importance and in the public interest, "The investigation of the sources of domestic water supply, particularly for large centres of population." Many of these watersheds are still Crown lands, and the Crown, as the land and water lord, is in a position to introduce practical conservation. During the past two seasons a field party has been continually at work following a set order in:—

(1) Determination of timber area.

(2) Cruising to determine how much timber is merchantable and whether the timber as a whole is a factor in the regulation of stream flow.

(3) Cruising of alienated timber.

(4) Extent of run-off.

(5) Obtaining the area of alienated land and the purpose for which it is held.

(6) The investigation of other rights, whether water or mineral, and the use to which they are put.

In a new country like British Columbia the value of this work must become of greater importance as time goes on. With the co-operation of an active Provincial Board of Health there will, in due course, be available data for the various centres of population that will be a guide in securing and guarding their sources of pure domestic water. The most important work in this respect now in hand is the survey investigation of the watersheds from whence comes the domestic water supply of Greater Vancouver. The results already obtained have enabled us to make equitable decisions in respect of licenses held by the municipalities who were at variance with one another. It is obvious that Vancouver must become a large city, a great railway and shipping centre. With this in mind we are compiling all the facts. The protection of Vancouver's source of domestic water supply has been rounded out to such an extent that when the time comes to provide for larger demands there will be few difficulties in the way.

Hydrographic Investigations.—When the province assumed from the Dominion the administration of water rights in the railway belt the latter decided to continue its hydrographic work in this section. It was, however, considered that it would be advantageous to the province if it could co-operate with the Dominion along lines similar to those in operation in the United States. An agreement accordingly was arrived at, and and we now have the British Columbia Hydrographic Survey. The officers of this organization have no administrative powers in respect of water rights. Outside the railway belt their whole time is devoted to hydrography, results of their work being available to the Water Rights Branch for administrative purposes. Our district engineers are thus to a large extent relieved of this work, except in sections where irrigation is practised, and proper administration depends on a direct knowledge of stream flow. In this respect we have, to some extent, adopted the system in use in Oregon, charts being prepared to show graphically the relation of records to stream flow, from which it may be seen at a glance those licenses that have to depend upon storage, and to what extent a stream may be recorded on.

I have referred to the lines of work of the district engineers as covering these three great purposes. And while I have stated that every line of work laid down has received attention in one or other of the districts, it has been impossible at the present date to give all the lines in each district the full attention they merit. For example, take "Duty of Water," a work that will demand the whole time of one man, who must specialize, and whilst this is so, it is not the intention to relieve the district engineers of their responsibility. On the contrary, their co-operation is essential, and they will be required to keep in touch with all work within their districts and to be here and there in the event of contentions arising.

In conclusion, if the administration of water rights is to count for anything, the requirements of the different sections of the country must be anticipated. To this end we have concentrated our efforts on the Okanagan Valley. By the end of another season every stream will have been traversed, every reservoir surveyed, every watershed determined, and the timber cruised; stream gauging all the while having been carried on. In fact, a thorough water investigation will have been completed in anticipation of development that is bound to come. The problem of well drilling in its application to bench lands is also under investigation; also the problem of irrigation by pumping with a view to obtaining and marshalling all the experience of other countries that we may apply them to British Columbia.

In the general conduct of the administration of water rights, whether at headquarters or in the field, we are endeavoring to follow the principles of good business by giving prompt attention to enquirers and water users; unbiased decisions where there is dissension; and in being thorough and comprehensive in field work and other investigations that we from time to time may undertake.

THE REGINA ENGINEERING SOCIETY.

At the annual meeting of the society, held recently, Mr. L. A. Thornton, works commissioner, Regina, was elected president, and J. M. Mackay, superintendent of waterworks, Regina, was re-elected secretary for the year 1914-15.

About 30 members took part in a visit to Moose Jaw on October 17th, where the city engineer, Geo. D. Mackie, had made elaborate arrangements, including a special street car and a group of automobiles, for showing the party about the various works of engineering interest in the city. Amongst those visited were the power station, where a demonstration of the recently installed high-pressure water system was given; the sewage disposal plants; the new Dominion Government internal storage elevator, and the Robin Hood flour mills.

The society's annual dinner was held in Regina on November 5th, the guests including His Honor Lieut.-Gov. Brown, Chief Justice Haultain, Wm. M. Martin, M.P., Regina; J. F. Bole, M.L.A., Regina; Robt. Martin, mayor of Regina, and Jas. Pascoe, mayor of Moose Jaw.

The next meeting of the society is being held in the Regina College at 8 p.m. on Thursday, December 3rd, the president delivering his inaugural address.

Editorial

PURIFYING RESERVOIR WATER WITH COPPER SULPHATE.

Interesting results have been achieved at the City of Gloucester (Eng.) in dealing with the nuisance, in the city's reservoirs for the supply of potable water, caused by the excessive growth of weeds which, decaying, created an offensive odor and gave an objectionable color to the water. At one time it was necessary to reduce the excessive growth of the weeds by the use of rakes—a process which involved considerable annual expense. As a consequence of experiments conducted by Mr. Geo. Embrey, F.I.C., the analytical chemist to the Gloucester County Council, the nuisance from the weed growth has now been effectually combated. The Witcombe reservoirs of the corporation were at the time choked with "Chara Vulgaris," a plant which is propagated by means of spores contained in an archegonium and fertilized by antheridia. The bursting of the archegonium sets free myriads of minute greenish cells which, with the countless anthrozoids, give the water a distinct color and a fishy odor. It was found that the use of copper sulphate in quantities of 1 to 1,000,000 was eminently successful in destroying the lower forms of plant life without injuring the fish or rendering the water toxic to human beings. One of the methods of applying the copper sulphate is to place the crystals in a canvas bag and trail this at the stern of a moving boat. Another method is to scatter the fine crystals over the surface of the water as in sowing seed, the crystals falling rapidly to the bottom of the reservoir before dissolving. This has an advantage over the former process where the solution is much diluted before reaching the bottom.

The three reservoirs of the Gloucester corporation have a total capacity of 120,000,000 gallons and the quantity of sulphate used is 400 pounds on each yearly application, or 1 to 3,000,000, which is found to be adequate to keep down the weeds. Each reservoir so treated is allowed to stand at least 3 days, and where possible a week, after the application, at the end of which period it is fit for domestic use and no trace of sulphur can be found in the water. The treatment, it has been found, is best carried out in the month of February, when the bottom of the reservoirs is usually covered with diatoms only; in March and April, under ordinary conditions, the confervæ make their appearance and later the Chara begin to grow. But if the sulphate treatment be applied in the early stages the diatoms are destroyed and neither the confervæ nor the Chara appear. Moreover, if the operation be performed with care and under proper supervision no danger need be feared.

NEW STEEL PLANT IN OPERATION.

Along with the encouraging reports of increased activity among steel companies has come the announcement from the Armstrong, Whitworth of Canada, Limited, that its new mill at Longueuil, Que., is practically completed and will commence business in all its branches before the month is ended. Although controlled by English capital, this company is essentially a Canadian manufacturing concern, employing Canadian workmen, and manufacturing grades of steel which, up to the present, have been scarce commodities in this country. A high-grade crucible steel for the manufacture of drills, taps, cutters, dies and other tools belonging to machine shop practice, will mark the initial activities of the new plant. Drop forgings will be started early next year, and it is the intention of the company to extend its present plant by the construction next season of a projectile shop.

Sir Percy Girouard is president of the company and the other directors are the Right Hon. Sir George Herbert Murray, P.C., C.B.; Saxon William Armstrong Noble, George Green Foster, K.C., and Matthew Joseph Butler, C.M.G.

PLANS TO REBUILD BELGIAN BRIDGES.

An important conference was held in Toronto last week by representatives of the Canadian Pacific, Grand Trunk and Canadian Northern railways, and of the Allan, Canadian Pacific and Canadian Northern steamship lines. The project under consideration was the rehabilitation of the numerous railroad bridges in Belgium and France, that have been destroyed in military operations. It was felt that the reconstruction of these bridges meant to Canada the employment of great numbers of men and the outlay of millions of dollars. Communications from the seat of war pointed out the enormous task which European engineers had before them in replacing railroad bridges in the shortest possible period of time, and bridge builders are of the opinion that field fabrication will largely give way to the transportation of entire sections of steel bridges from other parts of the country to the desired location. Discussion centered upon the steel bridges in possession of the railroads and not in use, since their removal to make way for heavier structures. It was stated that these released bridges, if laid down in Europe, could be of great service, as they might be immediately installed to replace those destroyed.

Those who took part in the conference were: J. L. Perron, solicitor for the C.P.R. and Montreal Tramways Company; Wm. Lyall, of the P. Lyall Construction Company; Timothy Foley, E. T. Foley and O. W. Swenson, of Foley, Welch and Stewart; W. F. Tye, civil engineer of Montreal; Patrick Dubec and Jno. Jenkins, Montreal railroad men; C. W. Allan, of the Allan Line, and Hugh Sutherland, of the C.N.R.

PROGRESS ON THE HUDSON BAY RAILWAY.

From Le Pas to Thicket Portage, a distance of 185 miles, the new line has been practically completed. It will be remembered that a year ago this portion of the line, known as Section 1, was graded for a distance of 130 miles and had received steel for 60 miles. Section 2, extending from Thicket Portage to Split Lake, a distance of 68 miles, has been graded and steel is now being laid. On Section 3, the remaining 165 miles between Split Lake and Port Nelson, considerable clearing and grading has been done. Officials of the Department of Railways and Canals, Ottawa, state that the work will be continued throughout the winter, and that completion of the Hudson Bay Railway may be looked for early in 1916.

SASKATCHEWAN LIGNITE.

THE sole sources of fuel in Southern Saskatchewan are the brown deposits of coal, which, in quantity, is estimated in billions of tons lying east and west of the Souris River. It is of marked woody structure, but its character throughout practically all the deposits is a true lignite of cretaceous age. A full report will shortly be presented by Mr. S. M. Darling, who is in charge of the government's lignite experiment station at Estevan. It will be looked forward to with interest, as this source of fuel and power premises bright prospects for the industrial future.

This lignite, as it is found in Saskatchewan, requires drying to eliminate a 30% content of water. It is then crushed to about 1 inch in size, the larger sized lumps of dried fuel being then suitable for burning on automatic stokers, while the smaller sized lumps pass on to the carbonizing oven for treatment before being briquetted.

Mr. Darling states that at Superior, Wisconsin, he recently dried a carload of lignite, briquetted it and burned the briquettes in a boiler test under the boilers at the Parliament Buildings, Regina. The amount of water evaporated per pound of fuel as fired was 6.36 pounds. Temperature of feed water 57° F. Last January in a test at the city power plant, using a good Alberta coal, under like conditions, the amount of evaporation was 6.5 pounds per pound of fuel as fired. "With equipment designed specially to handle this lignite," states Mr. Darling, "we can make briquettes that will be fully equal to the western coals is evaporative efficiency."

The lignite dust is very explosive. The drying plant must be equipped with explosive safeguards, and a plant equipped for the purpose can remove practically all of the moisture.

No byproducts are, of course, obtained where the lignite is simply dried.

The most profitable way to utilize the lignite is to carbonize it; that is, to distil off all volatile matter.

On carbonization, the products, in round numbers are:

1. Gas, per ton of lignite......	10,000 cubic feet
2. Oil or tar per ton	15 gallons
3. Ammoniacal liquor	35 gallons
4. Carbon residue	1,200 pounds

The gas has a heating value of 400 British thermal units per cubic foot and makes a good "town gas," for use in stoves and ranges. It is not a good illuminating gas; it is serviceable principally for fuel and power.

There is more gas in one ton of lignite than is required to carbonize the next ton. This surplus gas has a very direct bearing upon the matter of cheap power. Six thousand cubic feet of gas are required to carry on carbonizing, leaving a surplus of 4,000 cubic feet per ton to be used for power.

The market for domestic fuel, states Mr. Darling, is very large and it is not unreasonable to expect that the demand for carbonized lignite, for gas producers and domestic fuel in the shape of briquettes, will be sufficiently large to yield from the surplus gas all of the power required within a wide range of the lignite fields. The power derived from this surplus gas costs less than Niagara water power, $8 per horse-power year. If necessary, the amount can be augmented by using carbonized lignite in gas producers.

The oils and tars extracted from the lignite can be put to many uses—fuel oil, creosoting oil, leather preservative, water proofing, tar paper, roofing pitch, etc. The pitch makes an excellent binder for briquettes and will go far towards reducing the cost of this item. Almost all our coal tar dyes and other coal tar products have heretofore come from Europe, principally Germany. Several million gallons of creosoting oils for preserving timber have been imported annually. That supply is now cut off and the value of these materials on this continent greatly enhanced.

From the ammonia compounds is derived a substantial quantity of valuable fertilizer.

Lump carbonized lignite is the ideal gas producer fuel. The amount of gas is equal to that from anthracite pound for pound, but the gas is richer, has less tar and less clinker and burns more freely.

The 100 horse-power producer gas plant in the Leader Building, Regina, has used six carloads of this carbonized lignite, and on anything approaching a full load they got a horse-power on each pound of fuel. There are two dozen gas producer plants in this territory that will use this carbonized lignite when it can be supplied in sufficient quantities. It means a reduction of 30 per cent. in their fuel bills.

As a domestic fuel the carbonized lignite briquettes are fully equal to anthracite, ton for ton. They have a heating value of 12,000 British thermal units per pound as against anthracite's 13,000 British thermal units. But there is no clinker from the lignite briquettes, no loss in burning, and they can be used nicely in kitchen ranges, which is impracticable with hard coal.

This drying, carbonizing and briquetting of the lignite results in substantial economies from the standpoint of the mine owner. There is not the large waste in screenings as at present; every pound mined is used for some purpose. The product is put into such a condition that it can be stored indefinitely and shipped any distance without deterioration. This is not possible with the raw lignite, which can be mined only as it is used. The lignite mines are therefore idle a large part of the year. This ability to operate at a steady rate throughout the year, storing the products during the summer for shipment in winter, will effect a decided reduction in the cost of production.

To sum up:—

1. For domestic fuel for heating and cooking there are dried or carbonized lignite briquettes.

2. For steam raising purposes there are dried lignite for automatic stokers, dried lignite briquettes for hand-fired furnaces and powdered fuel.

3. For electrical power there is the carbonized lignite for use in gas producers at local points in different parts of the country; and, when the time comes, if it is not already here the surplus gas from the carbonizing process will be adequate to generate current at Niagara rates for distribution over a wide area from a central station at the mine.

4. Finally there is the utilization of the byproducts, which is bound in time to be a large industry in itself.

RAPID LINE WORK.

A construction gang of 9 men belonging to the engineering staff of the Hydro-Electric Power Commission of Ontario, is in possession of an excellent record for speedy construction. Between October 26th and November 10th it erected 450 steel transmission towers, and strung 8 miles of wire.

THE STRENGTH AND DESIGN OF WASHERS IN REFERENCE TO THE BEARING ON WOOD.

At the present time very few washers are designed with any idea of obtaining economy of design. An amount of metal is cast in a certain shape and trusted to hold the load to which it is to be subjected. But owing to lack of definite knowledge on the subject it is customary to add considerable unnecessary metal to a washer simply to insure safety. In the casting of washers, however, the cost varies directly with the weight and the question of an economical design should be a vital one. The common washer is essentially an uneconomical one in design and it seems possible that a design with less metal and sufficient strength could be obtained. It was with this in view that a careful study was undertaken by L. R. Rodenhiser, whose results appeared in a recent issue of The Cornell Civil Engineer.

The objects of his investigation were two-fold: (1) To determine the safe bearing value and ultimate strengths of different woods under different washers. (2) To determine the economic size of washers and their weights in order to make the first aim as high as possible and yet keep the weight of washers down to a minimum.

Four kinds of wood were selected and tested by the end test with the following results: Douglas fir, 9,000 lbs. per sq. in.; oak, 9,000; whitewood, 4,500; and white pine, 3,600 lbs.

The conditions of the test were as nearly like actual conditions as possible. A hole was bored in the wood the size of the hole in the washer and the two holes placed concentric. The loads except in two cases were applied by a nut. In those two cases an edge was used to apply the loads. The depression of the washer into the wood was very accurately measured.

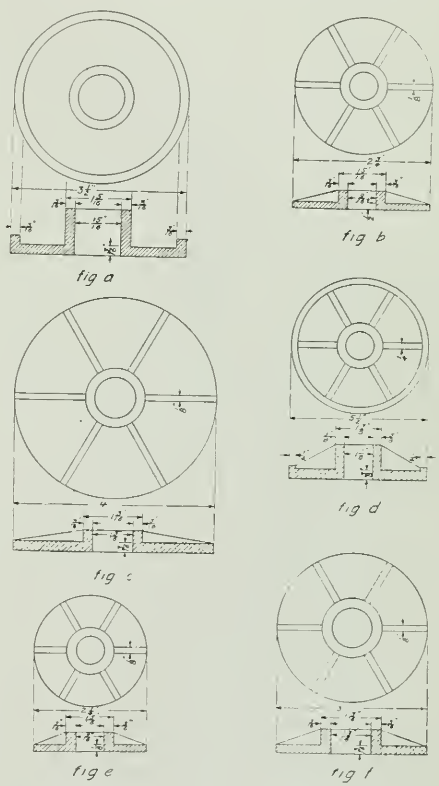
The timbers used in the testing were four feet long and were all 4 in. x 6 in. except the Douglas fir, which was 6 in. x 6 in. The wood was not selected but was taken at random from the stock of a local lumber-yard. From the results, however, the wood appears to have been well seasoned.

Professor Johnson's rule for determining the elastic limit was used. That is: the apparent elastic limit is the point on the stress of any material at which the rate of deformation is 50% greater than at its origin. In other words, it is the point of tangency of a line whose slope is 50% greater than that of the tangent through the origin. The washers that were designed for economic ones were designed for a bearing of 500 lbs. on soft wood and 900 lbs. on hard wood, these being just half the values found for the elastic limits by experiment. In the application of results it should be remembered that in commercial casting the bearing surface of the washers may be irregular and so cause uneven stresses in the wood. Also the quality of the metal used in commercial foundries is poor and variable.

Discussion of Results.—Tests were made to determine the advantage of spools on washers with the result that spools were found to increase the strength of the washer from 50 to 100% according to the size of the spool, without a proportionate increase in the weight of the washer. A test was made for a spool of greater height than that indicated in the above specification but no appreciable increase in strength was shown for the added metal.

An interesting set of tests was made with round-edged washers. It was expected that the round edge or the contact face of the washer would reduce the amount of the cutting and consequently the amount of the depression. On the first test the washer turned up on the edges so no satisfactory results were obtained. Further tests were made on stiffer washers but the results did not indicate any decrease in depression of the washer due to the rounded edge. In these tests the outside edge was rounded and no advantage was observed. It is thought possible that rounding the lower edge of the inside of the bolt hole may work to advantage by relieving the pressure from the fibers which were cut by the bit. However, no tests were made to determine this.

In the first tests the load was applied on a line but in each case the ultimate strength of the washer was so much less than when applying the loads by a nut that the



Some Practical Designs of Washers.

method was discarded and all subsequent tests were made with the load applied by a nut.

An important result was obtained from the tests on square washers. The ultimate strength of the washer was observed to be actually less for a square washer than for a round one of diameter equal to a side of the square one. On the tests on square washers the corners turned up and so caused the failure of the washer. It is supposed that the pressure on the corners, though being lower per unit area, has such an increased lever arm about the bolt that the bending moment in the washer is greater than it would be if the corners were cut off. In no case were square washers found to be of advantage. This information could be applied, it would seem, to the

design of plates for more than one bolt, where the corners could be rounded to increase the strength of the plate.

Two similar washers were tested, one with a rim 3/16 in. high and 3/16 in. wide around the edge, and one without the rim. The tests showed an increase in strength of 45% with an increase in weight of only 25% for the addition of the rim. The bearing at the elastic limit was 92 lbs. per sq. in. and the ultimate strength 1,050 lbs. per sq. in., the break occurring radially. The design for this washer is shown in Fig. *a*. Another test was made with the rim moved in ¼ in. from the edge but no advantage was discovered in the change and if ribs were used the rim on the edge would serve as a brace for these.

A ribbed washer with a 1/16 in. plate, and a 3/8 in. spool was found to stand a load of slightly less than 1,000 lbs. per sq. in. Considering the thinness of the plate this was remarkable. However, this washer was carefully made in Sibley foundry and can not be fairly compared to a similar commercially cast washer. While this design for a ¾ in. bolt weighs only 53 lbs. per 100 and is consequently economical, yet it is impractical to cast such a thin plate and the design should not be considered for commercial purposes. A similar washer with a ¼ in. plate and a ¼ in. spool cast in a local foundry proved about equally strong and much more practical. The weight of this design was 70 lbs. per 100.

An attempt was made to design a series of economical washers by using the features of advantage found in the above tests. Fig. *b* shows a soft wood washer for a ½ in. bolt. A ½ in. bolt will hold safely 2,000 lbs., the ultimate strength being from 6,000 to 8,000 lbs. The washer broke at 7,400 lbs. and may therefore be considered as an economical design since washer and bolt fail at about the same load. The weight of these washers is 30 lbs. per 100 while that for an Ogee washer for the same bolt is 37.5 lbs., thus showing a saving of 25% in cost. The wood was not stretched to its elastic limit so this design may be considered a safe and economical one.

Fig. *c* shows an economical design of a soft wood washer for a ¾ in. bolt. Such a bolt will hold safely 4,600 lbs., and on the first design with a ⅛ in. plate the washer stood only 8,500 lbs., which might be considered sufficient if all washers were uniform but as a factor of safety of at least four is desirable, it was thought advisable to raise the thickness of the plate to 3/16 in. This raises the weight from 63 to 75 lbs. per hundred but the Ogee washer for this bolt weighs 100 lbs. per 100, so that a saving of over 30% is effected by the use of this more economical design.

The tests for the 1-in. washers did not prove as satisfactory as the others. However, from the results obtained, it was considered that a washer of the design shown in Fig. *d* would be satisfactory. This design is also for a soft wood washer.

Fig. *e* shows a design of washer for a ½-in. bolt for hard wood. The washers were all in perfect condition at the end of the test, the failure occuring in the wood at 7,800 lbs. This washer weighs only 26 lbs. per 100 and may be considered as both safe and economical.

A design of a hard wood washer for a ¾-in. bolt is shown in Fig. *f*. The plate has been increased 1/16 in. in thickness over the one used in the test as that one did not prove quite strong enough for all purposes. The design shown would hold from 15,000 to 18,000 lbs. and as the safe stress on the bolt is 4,600 lbs. this is sufficiently strong for all purposes. The washers used in the test broke radially under a load of 1,820 lbs. per sq. in. The weight of the washer shown in the design is 50 lbs. per 100, which is 22 lbs. lighter than the Ogee washer for the same bolt.

The results have shown that the present design is uneconomical, and for three common sizes of bolts, designs for very economical and satisfactory washers have resulted from the experiments.

Conclusions.—The three main conclusions arrived at in the design of economical washers were:—

1. For bolts of less than ½ in. in diameter no reinforcement of the washer is necessary; a flat plate large enough to provide sufficient bearing area being all that is required.

2. For each inch of diameter of the plate there shall be 3/16 in. in height for the spool but no spool shall be less than ¼ in. in height.

3. For each inch of diameter of the plate there shall be 1/16 in. in thickness for the spool but no spool shall be less than 3/16 in. in thickness.

PUBLIC WORKS ON THE PACIFIC COAST.

OVER and above the expenditure connected with the construction of the new 1,150-ft. drydock at Lang's Cove, Esquimalt, B.C., the Department of Public Works of the Dominion Government has under construction in the province improvements amounting to $4,500,000. The Ogden Point breakwater, 2,530 ft. long, is under construction by Sir John Jackson (Canada), Limited, and is to be finished in about 15 months. It will cost about $1,800,000. The government has awarded a contract to the firms of Grant, Smith & Co., and McDonnell, Limited, for the construction of the first two piers. One side of the pier, the nearest the breakwater, will be 1,000 ft. long. The other side, and the sides of the adjoining pier will be 800 feet each. The width of the piers will be 250 ft. and they will be separated by 300 ft. of water of a minimum depth of 35 ft. at low tide. The piers will be of concrete cribbing filled in with rubble. The time limit of the contract is March, 1916. The amount of quarry run and rip-rap, which has been deposited for the foundations of the breakwater, is 673,197 tons, and the pier contractors have dumped 148,241 tons of similar material for levelling off a base for the cribs. A total of 12,940 tons of granite blocks has so far been laid by the breakwater contractors, and in connection with the land excavations 54,847 tons cubic yards of earth and rock have been removed.

The core of the breakwater has been built for the entire length, 2,500 ft. The core consists of 233,611 tons of small rock. The foundations on which the granite blocks will be set have been completed to within 700 ft. of the outer end of the breakwater. In connection with this work 439,586 tons of rubble has been dumped. The foundations are 20 feet below low water, and the rubble deposited included rocks of weight from 200 pounds to 16 tons. These foundations have been levelled off on the exposed side of the breakwater for a distance of 800 ft. from the shore. The granite blocks, weighing 15 tons, have been set in position by divers to a mark 500 ft. from the shore end and to a point 5 ft. above low water. The concrete superstructure has been prepared out 300 ft., and the contractors are now finishing the first block of this, which is 26 ft. in length.

Grant, Smith and McDonnell are concentrating all their work on pier No. 2. The western side of the pier is to have a length, as stated, of 1,000 ft. and rubble for the foundation of this face has been dumped to give a depth of 34 ft. below low water. The last foot of the

foundations is of very fine gravel in order to form a good bed on which the cribs will rest. On the western face of the pier, which is to be 800 ft. in length, rubble has been dumped for three-quarters of the distance. A portion of the foundations on the eastern face is now ready for the cribs. These cribs, each weighing 3,500 tons, are being built on a floating drydock of 8,000 tons capacity, which is now moored off the newly acquired quarry at Royal Bay. Earlier in the year the drydock was chartered from a Seattle corporation and during the past few months a large force of men have been engaged in equipping it with machinery and appliances to facilitate rapid progress in the construction of the cribs. Two cribs are to be put together simultaneously, the total weight when completed to be 7,000 tons.

Plans call for cribs of reinforced concrete 100 x 35 ft. in plan, with walls 39 ft. high and floors 2 ft. in thickness. In each there will be two longitudinal walls, 11 ft. 8 in. apart c. to c., and transverse bulkheads 10 ft. apart and 10 in. thick. Sea cocks will be provided in the floors for the purpose of admitting water to sink the cribs after they have been put afloat.

Twenty cribs are required for Pier 3, 22 for Pier 2, and 3 for the bulkhead between the piers.

The floors of the first two cribs have been constructed, forms for concrete are in place, and concreting has made extensive progress. It is expected that the pair will be ready for launching in a few weeks.

Mr. John S. MacLachlan is engineer-in-charge for the Government of this harbor work.

In the inner harbor, adjacent to the new Johnson Street bridge, the Dominion Government has under construction a wharf, which is to be completed by the erection of a new agency building for the offices of the Department of Marine and Fisheries, on a similar design to that of the building at St. John, N.B. Work on the building has been delayed by the indefiniteness of progress in the construction of the bridge.

At William Head quarantine station, where the passengers of inbound overseas vessels are examined, much needed alterations are being carried out.

For the Militia Department nearly $300,000 will be expended on the new drill hall, occupying a site on Bay and Field Sts., and McBride Ave. This building is now well on towards completion. The post office extension is also advancing rapidly, and will complete an imposing block in the heart of the city.

At Little Saanich mountain, near the city, an astronomical observatory is soon to be built to house a 73-in. reflecting telescope, the largest of its kind in the world.

The Provincial Government is completing the extensions to the legislative buildings, which will, when completed, represent a total investment of nearly $3,000,000 in Parliament Square. Some of the extensions have already been occupied by the various departments. The provincial goal, five miles out of Victoria, has just been finished, and the Normal School for Vancouver Island, situated at Mount Tolmie, overlooking the city, will be finished at the end of this year. Very large works are contemplated by the government on the old Songhees Indian reserve, which lies in the heart of the city. The Canadian Pacific Railway has constructed its terminals there, except the depot, while the Canadian Northern Pacific Railway also plans to erect for its island line, a depot connected with the Canadian Pacific Railway structure, the two joined to the city by the new bridge and a road through the reserve. To protect the area from erosion the two governments are co-operating on building a revetment wall costing $150,000.

MAINTENANCE OF EARTH ROADS.*

By George W. Cooley,
State Highway Engineer of Minnesota.

IN the consideration of this subject, it is presumed that the fundamental principles of road construction have been followed, *i.e.*, that an ample drainage system has been provided, and that the sub-grade or foundation has been built up without the use of perishable material. Unless the road has been so primarily constructed, weak spots will develop when the drainage is imperfect or where sods or vegetable matter has been used in its construction, and the cost of proper maintenance will become excessive.

In the construction of a new earth road made in an open level or rolling country, the use of an elevating grader is quite common and under suitable conditions its use is justified by economy in construction work, but its value as a road builder is lessened if the too frequent result is obtained of casting the sods into the road bed, and depending on the regular traffic to thoroughly consolidate the mass so built up. This can be avoided by the use of a tractor in hauling the grader, which thoroughly pulverizes and packs the material cast in by the grader.

We may safely take if for granted, then, that in any road bed carelessly constructed with a large percentage of vegetable matter, the future bills for repairs and maintenance will be governed largely by the quantity of unsuitable construction material used, and in case of a lax system of construction, a more elaborate system of maintenance must be adopted.

I quote the following from Mr. L. W. Page, director of the office of public roads:

Overtopping all other road problems in its importance is that of maintenance. The destructive agencies of traffic and the elements are unceasing in their activities, and it is idle to talk of permanent roads any more than to speak of a house, a fence or railroad ties as permanent. The public roads to-day, by reason of the exceptionally obstructive traffic conditions, are more costly in construction and this cost is continually increasing with the advance in the prices of labor and material. It is criminally wasteful, therefore, to invest large sums of public money in building the highways demanded by traffic, unless the investment is conserved by adequate maintenance.

We conclude, therefore, that continuous maintenance being such an important factor in the general scheme, especial effort must be made to install a satisfactory and economical system as soon as a road is opened to travel. In some of our western States, the plan has been suggested of requiring contractors on surfaced roads to provide for maintenance as soon as any section is completed, and continue the same for at least thirty days after the work is accepted, thus giving time for the engineering department to provide for the organization of a maintenance crew without overlapping or interfering with the work of construction; and in Minnesota the plan has been adopted in the construction of earth roads to require the continual use of a drag or planer on grade building. This latter plan has been found very efficient and renders future work on the surface less expensive, besides tending to produce a more compact road bed. The tool found most satisfactory in this work is that known as the "Minnesota Road Planer," which consists of the two blades of an ordinary road drag, fixed between a pair of runners about 14 feet long, the blades set at an angle of about sixty

*Read at Fourth American Road Congress, Atlanta, Georgia, November 9-14, 1914.

degrees to the runner and made rigid or adjustable as may be deemed best. The planer is hauled on a line parallel with the axis of the road and its operation is similar to that of the ordinary drag, with the additional advantage of making a smoother surface. The old style drag without runners has a tendency, especially on new work, to increase the "waves" or undulations frequently occurring on road construction, while the planer eliminates these faults, and as a general maintenance tool has proven the most satisfactory.

An important feature of maintenance is prevention of the growth of sod and weeds along the travelled track. When sod is allowed to form along the highway, it has a tendency to catch the dust and wash from the road surface, and soon becomes a high, tough shoulder, preventing drainage. The use of a spring tooth harrow along the roadside two or three times a year will prevent this growth.

The State of Minnesota has given special attention to the matter of maintenance and in the present road laws has made adequate provision for the care of all roads. Township and county roads constitute approximately 90 per cent. of the road mileage of the State, and of these roads, about 90 per cent. are earth roads. To care for the town and county roads, a one mill tax is levied on all property in the town, the proceeds of which constitute the town dragging fund. This fund is expended under the direction of an overseer, appointed by the town board, for the purchase of drags, and in dragging all roads of the town, excepting State roads. This appears to be the most satisfactory method of caring for the earth roads under control of the local authorities, but there should be a provision in such cases for general supervision of the work by the county highway engineer.

For the care of State roads in Minnesota, 20 per cent. of the State road funds, with a due proportion of county funds, are set aside and may not be used for any other purpose than maintenance of State roads. As the State roads include all types of construction, different systems of maintenance have been required in the different localities. In general, three systems have been established: The patrol system on macadam and well built gravel roads, and the maintenance section system, and road drag system on other roads, all being under the direct supervision of the district highway engineer.

Under the patrol system, one man is assigned a section of from 5 to 7 miles of road and works with hand tools. It has been found necessary to supplement this work with the occasional use of a team and in that manner it has proven satisfactory on macadam and gravel roads.

Under the maintenance section system, one man is given charge of a section of from 20 to 30 miles of road and is employed continuously with his team on the care of his section. He is given authority to employ additional help, both teams and men, and usually has two teams and four or five men at work. Contracts are also entered into by the section foreman with residents along the road, for the dragging of same after each rain, or when ordered to do so by him. The section crew takes care of all minor items of construction, such as placing culverts, etc., and we have found that the work when properly done, is really of a constructive nature. This system is without doubt the most effective, and is being adopted generally throughout the State.

The dragging system requires the employment of a superintendent of maintenance, who for convenience should be one of the engineer's assistants, whose duty is to contract or make arrangements for the dragging of all roads under his charge, and to see that the work is done at proper times. This system is suitable for slightly undulating prairie country, where most of the roads are of earth, and to get best results, the superintendent should have at his disposal light graders to re-shape the road bed at least at the beginning of each season.

On earth or gravel roads, no maintenance system is complete which does not contemplate the use of planers or similar devices, and a combination of work as outlined under the section system is recommended.

SUMMARY OF TUNNELING PRACTICE.

THE following has been adopted by the American Railway Engineering Association in accordance with the findings of its Committee on Roadway with respect to methods of tunnel construction.

Tunnel Construction.—Railway tunnels, as ordinarily constructed, are more economically built by driving the heading entirely through, first, but such method usually requires a greater length of time for completion of the tunnel.

For material requiring support, the top heading should usually be driven.

It is economical and expedient to use an electric shovel or an air-shovel, for the removal of the bench where the section of the tunnel permits the safe operation of the same; and where the material does not require support there are advantages in low cost and quick removal of the bench in driving the heading at the sub-grade line.

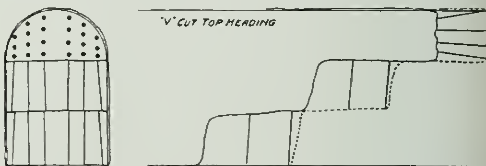
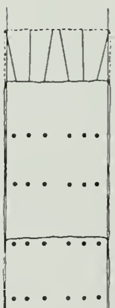


Fig. 1.—Construction in Hard Rock With Few Seams.



Where the time limit is of value, the heading and bench should be excavated at the same time, the heading being kept about 50 ft. in advance of the bench. Where the material of the roof is not self-supporting and timbering is to be resorted to, the bench should not be removed until the wall-plates are laid and the arch ribs (or centering) safely put up.

Opposing grades should preferably not meet between the portals of a tunnel, so as to put a summit in the tunnel, and where practicable the alinement and ascending grades in the tunnel should be in the same direction as the prevailing winds.

Figs. 1, 2 and 3 are representative of American practice in single-track tunnel construction, where the time limit is of value. Fig. 1 relates to tunnel construction in hard rock with few seams.

Heading in material of this kind is usually driven by a "V" cut, using from 16 to 22 holes about 8 ft. deep. The holes near the middle of the heading are drilled so as to nearly meet at the end. These holes are the first row shot, then the second row and outside holes last. The arrangement of these holes will vary slightly according to the way the material breaks.

Bench in hard material of this kind is usually taken out in two lifts of almost equal weight. Sub-bench is drilled from 20 to 40 ft. in advance of the bench. From 4 to 8 holes in a row, with about 6 to 8 ft. face, are used in both sub-bench and bench. One or two rows of holes may be used. Centre holes are shot first, round and side holes last.

In Fig. 2 the method of construction in moderately hard rock with seam, is illustrated. Heading in material of this kind is usually driven by a "hammer cut," using

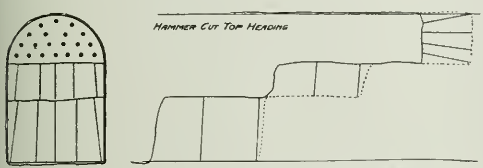
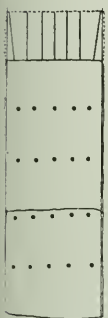


Fig. 2.—Construction in Moderately Hard Rock With Seams.



from 14 to 20 holes 6 to 10 ft. deep. The bottom row of holes is inclined at about an angle of 30 degrees. The bottom row is shot first and each row shown in succession. These holes should be arranged to suit the seams in the material.

Bench in material of this kind is usually taken out in two lifts, but the sub-bench is not as deep as the bench. Sub-bench is best drilled from 20 to 40 ft. in advance of the bench. From 4 to 6 holes in a row may be used with 6 to 10 ft. face. The bench is sometimes taken out in one lift. Centre holes are shot first, round and side holes later.

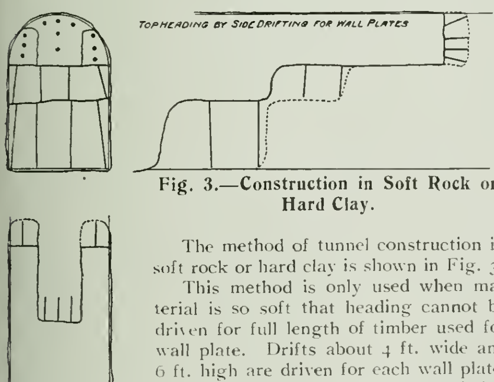
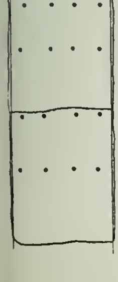


Fig. 3.—Construction in Soft Rock or Hard Clay.



The method of tunnel construction in soft rock or hard clay is shown in Fig. 3.

This method is only used when material is so soft that heading cannot be driven for full length of timber used for wall plate. Drifts about 4 ft. wide and 6 ft. high are driven for each wall plate, and then core is taken out as timber rings are put in. Three or four holes may be used from 3 to 5 ft. deep in each drift. The amount of shooting necessary depends entirely upon the softness of the material. It can often be picked. The core may be soft enough to pick, or may be shot with from 4 to 8 holes, either drilled from face as shown or from sides of drifts.

Bench in this class of material is shot in one or two lifts. Very few holes are necessary.

Coast to Coast

Vancouver, B.C.—The new $300,000 immigration building is now under construction. Messrs. Snider Brothers and Brethour are the contractors.

South Vancouver, B.C.—A number of water mains will necessarily be lowered in the near future, owing to grading operations now being carried on by the city and adjoining municipalities.

Peterborough, Ont.—The new line of the Grand Trunk Railway between Belleville and Lindsay has progressed so rapidly that steel now extends over half way between Belleville and Peterborough. It is probable that this portion of the line will be completed before the end of the year.

Ottawa, Ont.—On the Hudson Bay Railway steel has now been laid on 180 miles of the total 420 miles to Port Nelson. Grading has been completed on 325 miles. Construction work this season has been handicapped by bad weather, but it is expected that the close of next year will see the steel laid completely to tide water.

Cobalt, Ont.—The new high-grade vein on the Savage property is estimated to average between 7,000 and 8,000 ounces to the ton over an average width of 4 inches. It was located at the 140-ft. level, and has been proven for a depth of 55 ft. This vein was encountered in the cross-cut driving through virgin territory from the 140-ft. level.

Chatham, Ont.—Civic improvements this year have been extensive. The programme in the matter of sidewalks was completed last week. Three reinforced concrete pavements and a bitulithic pavement have been laid in addition to numerous other pavement improvements. The sewerage programme will have been completed by the end of the week.

Montreal, Que.—To the Home Guard has recently been added a company of 250 men from the Canadian Pacific Railway Co., arms and equipment being supplied by the company. Half of the number is being enrolled from the Angus shops and the other half from the Windsor and Place Viger stations. It is intended that miniature rifle ranges will be established at Angus and Windsor station.

Toronto, Ont.—Good progress has been made by the city on the large trunk sewers in Ward 7. The work has been handicapped on both the Woodville Avenue and Humberside Avenue conduits by the intrusion of water, but steam pumps have been constantly in commission, and the work has proceeded without interruption. Both are rapidly nearing completion.

Regina, Sask.—The new Regina jail, a 3-story building of brick and reinforced concrete, has been completed. It is six miles from the city. Power is supplied by two semi-Deisel engines with direct-connected generators. This power is used for lighting, ventilating, water supply, laundry, while a motor is also used for operating the septic tanks at the sewage disposal works.

Fort George, B.C.—The Pacific Great Eastern Railway has now a force of nearly 7,000 men along its route between Squamish and this city, and it is expected that the entire route will be graded before the close of the year. Track will extend to Lillooet by the end of January, and it is hoped, to Clinton, by June. The entire line should be completed from tide water to Fort George by the close of next season.

Vancouver, B.C.—Traffic to the coast by way of the Kettle Valley Railway will likely be accommodated next summer. The Kootenay Central Railway is also well on the way to completion, the swing bridge over the Columbia River, near Lake Windermere, having recently been put into

position. Construction on this line has been carried on northwards from the Crow's Nest line and southwards from Golden, and the two sections will meet at the Columbia River bridge.

Toronto, Ont.—Owing to the present unsettled conditions, it is a question whether the next session of the Provincial Legislature will draft an extensive programme of construction in the matter of highway improvements in Ontario. During the past season much work has been done by the Public Roads and Highways Commission by way of investigation, compilation of statistics, traffic census, etc., and, under normal conditions, legislation should shortly be introduced, providing the necessary machinery for carrying the policy into effect.

Viking, Alta.—Natural gas has been struck near Viking, Alta., on the Grand Trunk Pacific Railway. The well has been bored for the city of Edmonton, and the gas will be piped to Alberta's capital, eighty-two miles distant. The well is 2,340 feet in depth, and is making 9,350,000 cubic feet per day. This well is only exceeded in size of flow on the continent by the one at Bow Island. It is stated that two wells of this capacity would supply all the power, light and heat required in the city of Edmonton.

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA.

On December 1st a large attendance of the membership of the Society heard Mr. J. S. Plaskett, D.Sc., of the Dominion Observatory, who delivered an illustrated address descriptive of the new telescope now under construction for the observatory at Victoria, B.C.

At its next meeting, on December 15th, the Society will be addressed by Prof. L. B. Stewart, University of Toronto, on "Experiences on Surveying and Exploring Expeditions." The address will be illustrated. Mr. A. F. Miller is secretary of the Society, whose offices are at 189 College Street, Toronto.

PERSONAL.

R. S. BUCK, chief engineer of the Dominion Bridge Co., Montreal, has been appointed maintenance-of-way engineer for the New York Railway.

JAS. SHIELDS, consulting electrical contractor, has been chosen by the Toronto Hydro-Electric System as inspector of city wiring.

J. L. HARRINGTON, consulting bridge engineer of Kansas City, addressed the Victoria branch of the Canadian Society of Civil Engineers at its recent meeting on modern bridge construction.

GEO. GAUTHIER, assistant superintendent of the Montreal Light, Heat and Power Co., was seriously burned by a short circuit at one of the plants of the Shawinigan Water and Power Co. last week.

A. F. STEWART, chairman of the Toronto branch of the Canadian Society of Civil Engineers, delivered an illustrated address to the members of the Branch at a meeting on November 26th. His subject was "Bridges Destroyed during the South African War."

D. C. COLEMAN, of Calgary, general superintendent of the Alberta division of the C.P.R., will, it is reported, succeed Mr. Grant Hall as general manager of Western lines, the latter advancing to the vice-presidency vacated by Mr. George Bury, when Mr. Bury moves up to succeed Mr. McNicoll.

OBITUARY.

The death occurred last week of Mr. John H. Housser, secretary and one of the directors of the Massey-Harris Co., Toronto. Mr. Housser was connected with the firm for 42 years.

The death occurred in Montreal last week of Mr. R. C. Hadley, of the engineering staff of the George A. Fuller Contracting Co.

It has been announced that Mr. Fred. C. Robertson, inspector of C.P.R. Telegraphs for Ontario, died on November 29th at Port Hope.

The death occurred last week of Mr. A. E. Wilkinson, traffic superintendent of the Intercolonial Railway in Nova Scotia. Mr. Wilkinson was in his 45th year, and was a native of New Brunswick.

NEW G.T.R. BRIDGE AT PRINCE GEORGE, B.C.

The vertical lift-bridge over the Fraser River at Prince George, B.C., was opened last week to permit the passage of steamers. The lift-span is 100 ft. in length, and is electrically operated, assisted by concrete counter weights. When raised, it is 150 ft. above the river. The entire bridge is one of the longest steel bridges in the Dominion, being 2,654 ft. between abutments. There are twelve spans, excluding the lift portion. The structure rests on 14 concrete piers, and provides accommodation for two 12-ft. roadways and a 19-ft. railway right-of-way.

COMING MEETINGS.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.

AMERICAN ROAD BUILDERS ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.—Annual Convention to be held at the King Edward Hotel in Toronto, January 26, 27, and 28, 1915. Secretary, G. C. Keith, 32 Colborne Street, Toronto.

EIGHTH CHICAGO CEMENT SHOW.—To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.

AMERICAN WATERWORKS ASSOCIATION.—The 35th annual convention, to be held in Cincinnati, Ohio, May 10th to 14th, 1915. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—Annual meeting to be held at the Iowa State College, Ames, Iowa, June 22nd to 25th, 1915. Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Officers of University of New Brunswick Engineering Society:—The Engineering Society at the University of New Brunswick elected their officers, recently, as follows:—Honorary president, Mr. Wallace Broad, St. Andrews; president, Prof. J. A. Stiles; first vice-president, Mr. E. McL. Balkam; second vice-president, Mr. J. P. Mooney; treasurer, Mr. J. D. Hickman; secretary, Mr. A. C. Edgecombe.

Volume 27. Toronto, December 10, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

STORAGE DAM AT EUGENIA FALLS

PLANT AND METHODS EMPLOYED IN THE CONSTRUCTION OF THE CONCRETE-STEEL SECTION OF DAM ON BEAVER RIVER FOR THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO.

By G. R. HECKLE,
Managing Director, Ambursen Hydraulic Construction Co. of Canada, Ltd.

IN estimating the cost of carrying out any construction project two factors of the greatest importance are the time in which the work must be completed and the plant to be employed. These two factors are practically analogous, as, of course, the capacity of the plant governs the time required. If the capacity of any unit is not as great as was estimated, moreover, there is a grave probability that the other units of plant may be delayed in employment, and while their capacity may be as large as estimated, they may be unable to carry the extra load occasioned by the delay of some one unit, and the whole schedule of operations may therefore be completely disorganized. As the "overhead" charges, such as superintendence, maintenance of plant, etc., are all based on the estimated duration of the work, they immediately start to increase as a relative percentage of the other work, and the contractor's estimate of profit is possibly absorbed in the process.

In the old days of contracting when manual labor was largely employed, there was less liability for an error in judgment with regard to the time and cost, as the forces employed were much less complex, and more laborers could be easily added or more work could be produced by better management from a given number of men. In modern contracting, however, when the plant is once installed the time and expense of replacing any units which may fall below their estimated capacity will in all probability eat up the profit and possibly more, so that it is of great importance that first calculations be on the safe side, and a considerable margin be allowed for contingencies.

With the above preamble, the writer begs to call attention to a contract for the construction of a concrete-steel dam of the Ambursen type for the Hydro-Electric Power Commission of Ontario, which is now nearing completion. The work is located at Eugenia Falls, Ontario, about eighty-five miles west of Toronto, and about thirty miles east of Owen Sound, the site of the dam being about seven miles from the railroad. The dam will furnish storage for a power development on the Beaver River, which is being constructed and will be operated by the Hydro-Electric Power Commission. The total length of the structure is approximately 1,900 feet, of which 1,260 feet is Ambursen section and 640 feet is earth embankment with concrete corewall about equally divided at both ends. The Ambursen section is approximately 51 feet high from bottom of cut-off to top of crest at the highest section; the total concrete required for the entire work being about 10,000 cu. yds., practically all of which is in comparatively thin reinforced sections, and distributed over a large area. The stripping of the site involved about 14,000 cu. yds. of earth excavation and about 2,500 cu. yds. of rock, principally in the cut-off trench, which is in a stratified and seamy limestone and which has an average depth of about ten feet.

The contract for the construction of this dam was closed with the Ambursen Hydraulic Construction Company of Canada, Limited, in the latter part of June of the present year, and the company guaranteed to complete the dam to within fifteen feet of the crest by December 25th of this year, so that water from the spring freshet of 1915 could be stored for power purposes, the entire dam to be completed by July 1st, 1915. The work was undertaken on a unit price basis with liquidated damages for non-completion to the elevation noted previously at the date specified. The latter stipulation required that the dam should be entirely completed with the exception of about 2,000 cu. yds. of concrete in the top lift in a period of about six months from the receipt of authority to proceed, and it was obvious that in order to accomplish this result it was very necessary not to overestimate the plant capacity.

In a general way the following plant and methods formed the basis of the estimate: A Bucyrus traction steam shovel of ⅞ cu. yd. dipper capacity for earth excavation, equipped with 1-yard capacity dump wagons; air drills of the Holman hand-hammer type for the rock excavation; a 1-yard capacity Smith mixer; a cableway of five tons capacity and about 1,325 ft. clear span of our own design, for distributing concrete and handling forms, and Dowd 1-yard capacity controllable bottom dump buckets for concrete. A guy derrick equipped with a three-drum 8-in. x 12-in. Beatty engine, with Dake swinger operating a 1-yard Hayward orange peel bucket, dredged gravel from a pit adjoining the dam, which was

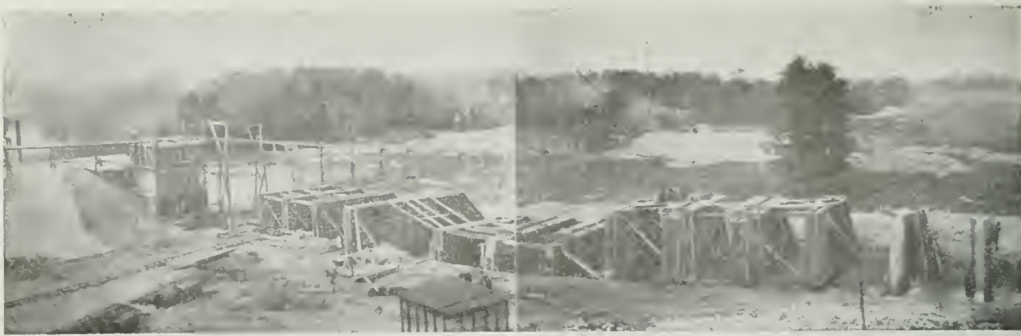


Fig. 1.—South Half of Dam at Eugenia Falls, as it Appeared on September 15th, 1914.

dumped into the hopper of a screening and washing plant, consisting of two revolving conical screens of ⅜-inch and 3-inch diameter holes respectively with automatic sand hopper of the Gilbert type. The product of this plant was hauled over the dam and gravel and sand bins on an inclined trestle by a small hoisting engine, and was either dumped directly into the bins or into storage piles immediately adjacent. By operating this plant day and night, the entire amount of sand and gravel required was furnished by about the last of October, and the derrick was then transferred to the storage piles for loading the bins, the difficulties due to operating a washing plant in freezing weather being thus avoided.

Steam power for operating the above plant, with the exception of the shovel and derrick, was furnished from two 40 and one 50-h.p. boilers of locomotive type, and the water for the sand and gravel washing was furnished by a 4-inch pulsometer assisted by a 2½-inch duplex boiler feed pump, another pulsometer also being used for unwatering the river section. For night work a small motor-generator driven by a steam engine furnished electric power for arc lights suspended from a cable attached to the cableway towers and spanning between them.

A small machine shop and carpenter shop were established immediately at the start of the work, the former being equipped with the usual blacksmith outfit, bolt machine, drill, pipe threader and cutter, and hand-lever shear for cutting reinforcing steel. The carpenter shop was equipped with band saw and air augers, driven by locomotive compressor of the Westinghouse type.

Fig. 1 shows the south half of the dam as it appeared on September 15th. At the left are seen the mixing plant bins and storage piles of gravel and sand. On the opposite side can be seen the screening and washing plant with derrick for loading. It will be noted that the mixing plant is approximately at the centre of the dam, thus cutting down the transportation of concrete by the cableway to a minimum.

With this general summary of the plant employed, it may be of interest to describe briefly its operation, and results obtained.

The shovel easily stripped ahead of the rock excavation and concrete work, and was afterwards employed in feeding the orange peel with gravel, thus saving the time and cost of moving this plant when the adjacent supply of gravel had been exhausted. It was also used for making the earth embankments at both ends of the dam.

The cut-off trench was carried on night and day, as it was much deeper than was anticipated, on account of the seamy nature of the rock, and the concrete plant was delayed somewhat in starting on this account. This trench had to be drilled and blasted with the greatest care to avoid disturbing the seamy rock as much as possible, and was the most difficult factor to contend with, with regard to both cost and time during the carrying out of the work. It was with great difficulty that rock excavation was kept from continually delaying the form and concrete work.

The form work was carried on in two shifts, one being of twelve hours, to take advantage of as much day-

Fig. 2.—Dam and Cableway on October

(Mixing Plant on Left; Screening and Washing Plant in Background.)

light as possible and the other of ten hours during the night, when the cableway was available for moving forms. In this way the required capacity from the concreting plant could be obtained by properly systematizing the gangs employed in form erection and stripping.

The progress of concrete was estimated as follows: Plant to be in operation about August 1st, figuring that this would insure approximately one hundred working days before December 25th, after deducting for Sundays and bad weather. To pour 8,000 yards in this time an average of 80 cu. yds. per day would be required. It was therefore apparent that one mixer would be more than sufficient, and that the form work was the governing factor. It was also apparent that the concrete plant had a large reserve capacity in case the estimated time of erection should be cut down, as turned out to be the case. It had been estimated that sufficient cut-off trench could be prepared by August 1st, while the plant was being erected, to allow form work and concreting to proceed at that date. On account of the much greater depth of cut-off required, however, and uncertainty at the start with regard to certain horizontal clay seams encountered, it was practically September 1st before the first concrete was poured. On account of this delay it was therefore necessary to exceed the estimated average progress of 80 cu. yds. daily, by at least 25 per cent., raising the rate to an average of 100 cu. yds. per day, and this condition was fully met by the concrete plant and form work, as shown in the following record.

During the month of September the average pouring was 99 cu. yds. of placed concrete per working day. In October the daily average was 140 cu. yds. In November the average for the month dropped to about 90 cu. yds. on account of stormy weather and the fact that most of the work was confined to the small sections at the top of the dam. This record, however, showed that the plant had placed in 78 working days about 9,000 cu. yds. of concrete, or an average of 112 yards per day, and that the "factor of safety" in its capacity was sufficient to make up for the unforeseen delays which had limited its working time. A large factor in the average attained was the high speed of the cableway, which easily reached a travelling speed of 1,500 feet per minute in operation.

Fig. 2 is a general view of the dam and cableway on October 20th, and in the direct foreground are two cars from the gravel plant starting up the incline to the mixer bins and storage piles. The top of the concrete at the left of the picture is about 15 feet below the crest of the completed dam.

Mr. F. A. Gaby is the chief engineer of the Hydro-Electric Power Commission, and the work has been directly under the department of Mr. H. G. Acres, hydraulic engineer. Mr. T. H. Hogg is responsible for matters pertaining to design and Mr. A. D. Watts is resident engineer for the Commission. Mr. A. J. Raymond is superintendent in charge for the Ambursen Hydraulic Construction Company, and Mr. G. A. Johnson is the company's engineer on the work.

20th, 1914. View from Central Point.

STEEL PASSENGER CAR FRAME CONSTRUCTION.

A PAPER presented at the December 3rd meeting of the Mechanical Section of the Canadian Society of Civil Engineers, by Mr. C. Brady, discussed in a very enlightening manner the differences existing in different types of frame construction designed for like loads and stresses. Mr. Brady emphasized the impossibility of drawing satisfactory conclusions as to the merit or weight of any particular type of framing when comparing cars built by different designers for different roads. This for the reason that variations in proportion and in size of plates and bars, together with different weights of other parts of the car and different general dimensions throughout, do not admit of close comparison. But the writer presents some interesting data respecting the four distinct types as they are actually built. These types are described as follows:

(1) Heavy centre sill construction, the centre sills acting as the main carrying member.

(2) Side carrying construction, the sides of the car acting as the main carrying member having their support at the bolster.

(3) Underframe construction, in which the load is carried by all the longitudinal members of the lower frame, the latter being interpreted to include the side girder below the windows.

(4) Combination construction, in which the side frames carry a part of the load, transferring it to the centre sills at points remote from the centre plates, so as to utilize the uniform centre sill area.

The writer does not submit particulars respecting the first type of construction, as it is quite unequal to the others in weight. Types 2, 3 and 4 are analyzed in detail with respect to the above considerations, and the reader is given a clear insight into what to look for in examining cars in service, or more especially, when the opportunity presents itself, to examine cars that have been in accident. The great importance of a minimum weight for a given standard strength is clearly emphasized. Ability to support its own weight and the usual maximum live load is brought out in the case of each, and each is proven entirely satisfactory in that regard. The same is said of end shocks in coupling and uncoupling, and in collisions, so long as the cars remain on the track in the same horizontal plane.

The condition that usually results in numerous injuries and loss of life is the telescoping of cars, as it is called, when the underframe of one car gets above the underframe of the next car and plows through the comparatively light superstructure. When this occurs it is impossible to express what happens in terms of a static load at a given location, but it has come to be generally accepted as inevitable that some damage must result to the vestibule and car end no matter what construction is used. The greatest protection to passengers is effected by making the end construction very strong, not necessarily to resist bending but rather to prevent tearing away at the fastenings. As a telescope contemplates conditions where the centre sills are not in line, some exponents of the comparatively light centre sill construction argue that the very large and powerful centre sills do not afford any additional protection but are actually objectionable because of the increased probability of their tearing away the end superstructure.

For resisting end shocks above the floor level, side swiping and bending, Type 2 is shown by the writer to be stronger than the others on account of the comparatively heavy top plate angle and the stronger post construction.

Advantages for the large heavy centre sills are not so easy to find, but there is one important condition where they would probably show up to advantage and that is in case of a collision where a locomotive strikes the car. A modern locomotive would not be at all likely to climb into the car, and if the speed was great even the heaviest car construction could not be expected to stand up against the massive castings and heavy steel plates used in locomotive construction; but it is quite reasonable to presume that the stronger the centre sill construction in the car the less the damage which would result.

From construction and operating standpoints the shallow centre sill car has the advantage of not interfering in any way with the locating of brake rigging and other equipment under the car, and it materially facilitates quick and thorough inspection in service.

ST. CATHARINES VIADUCT PLANS TO BE REVISED.

The proposed St. Paul Street bridge at St. Catharines, over the old Welland Canal, a description of which appeared in *The Canadian Engineer* for November 26th, 1914, is to undergo a slight change in plan to provide sufficient carrying capacity to accommodate the proposed Hydro-Electric railway between Windsor and the Niagara River. It has been decided to increase the strength of the bridge by approximately 20%, and the companies now tendering on the superstructure are being notified to that effect.

The bridge, as described in the article referred to, was designed to carry a 36-ton car, whereas, a 57-ton passenger car will probably be the requirement of the Hydro.

Although the Hydro-Electric Power Commission is probably not contemplating the early construction of this electric trunk railway line across the western peninsula, members of its engineering staff have conferred with the St. Catharines authorities in an advisory capacity with respect to the wisdom of providing for the future installation.

CANADIAN MANUFACTURE OF SHRAPNEL SHELLS.

As announced in these columns some weeks ago, the British War Office has awarded, through the Department of Militia at Ottawa, a number of contracts for the manufacture of shrapnel shells to different Canadian firms. It has just been announced that these contracts aggregate the sum of $2,500,000, and that practically all the material entering into their construction is being obtained in the Dominion. For instance, the Nova Scotia Coal and Steel Company supplies the steel, the Trail smelters in British Columbia supply the lead, and like materials come from various parts of the Dominion.

At present, about 200,000 shells have been contracted for, and they are being turned out at the rate of 30,000 a month. It is stated that there is capacity in Canada for the manufacture of 100,000 or more per month. The work is now going on at Montreal, Sherbrooke, New Glasgow, Amherst, St. John, Kingston, Toronto, Welland, St. Catharines, Hamilton, Dundas, Galt, Ingersoll, London, Lindsay and Smith's Falls.

IMPROVEMENT OF ORDINARY COUNTRY ROADS.*

By S. P. Hooker,
State Superintendent of Highways of New Hampshire.

IN a subject of this kind the first question to determine is the exact meaning of the title. What is light volume mixed traffic? How many vehicles are to pass over a given piece of highway and still be classed as light volume? What is their relative proportion as to motor-propelled and horse-drawn? The right interpretation of these terms is not clear. There are sections of the country where presumably the mixed traffic would consist almost entirely of horse-drawn vehicles, while in others a very large per cent. would be motor traffic.

The treatment of the surface of these two subdivisions would vary to a considerable extent. The writer is inclined to consider the subject as being the treatment of subsidiary roads which have only the horse-drawn traffic originating upon the road, together with motor traffic of the pleasure class and little or no freight traffic which is motor-driven.

With the immense mileage of roads, it would seem that a large proportion of the roads will never be improved under the types of construction which are now considered necessary for their improvement and that 90 per cent. of the entire mileage will be unimproved if it is necessary to improve them with the higher types of construction.

There must be a revulsion of feeling which will compel more mileage and lesser cost Given, then, a country highway as it now exists and the proposition that for 10 miles of this road there is only available the sum of $25,000, what can we do to render this really an improved road which, under proper maintenance, will take care of the traffic upon it? A preliminary survey may show that a portion of the road is in a low-lying level section without proper ditches where at present the natural tendency of the road is to act as a sort of drainage canal for lands adjacent to it. The soil itself consisting partially of leaf mold containing a large amount of humus and which if used as a cultivated field would produce good crops.

The next portion may consist of a sand and gravel formation, containing boulders and on a grade of from 5 to 8 per cent., rolling over elevations and into hollows and gullies and eventually working out into clear deep sand. Succeeding this may be a hollow from which you rise upon a side hill cut through a clay bank. Here you face the proposition that the clay is of such a nature as to practically absorb all the water and where your drainage condition is most difficult to handle. Your last section may be through ledge of native rock or large boulders, the soil slightly covered with either hard-pan or sand and upon grades which easily wash under the annual rainfalls.

On almost all country roads several of these conditions will ordinarily appear, while, of course, it is an exaggeration that they will all occur within the 10-mile stretch.

Confronted with these conditions, it seems to be absurd to attempt a standardization of such a highway in order to economically work out the problem. The material which is comparatively local must be used and the treatment of each section will be different.

The width of the present highway must first be taken up and, in general, standardized for the ordinary traffic, probably a width of 21 feet between ditches is the most satisfactory standard and considering that this should be accepted as the width of the road, you are next confronted with the alignment and drainage.

In all probability the alignment will be comparatively easy over the level, fertile section, but the drainage on this section will be a problem. Here, in general, you must first provide by deep ditching for reducing the water level of the surrounding land and by deep ditching is not meant the ordinary ditch from which the crown of the road rises, but in many instances a ditch which acts to a considerable extent as a drainage canal.

Culverts must be provided at all points where the drainage may be taken away from the road at every accessible point, and however level the plain or plateau may be as a whole, you will doubtless find a large number of places by which the water will be conveyed entirely away from the road.

In most instances the grading material obtained from the ditches, though seemingly of very inferior quality, may be used to raise the general grade of the road and, if kept dry by the side ditches, will compact and make a fair subgrade.

The next essential is to obtain upon such raised grade a sufficient quantity of metal of some kind to prevent the cutting through of the road surface from water which falls upon the road or in flood seasons cannot be entirely carried away by the ditches. This may be obtained either from fields, stone fences or even drawn from section two, which has an entirely different soil. In some places it would be necessary to practically lay this stone as telford. In other places it is enough to simply dump it in the road and only partially place it by hand labor. In many places where a roller is available this may be the method and the stone simply forced into the soft material excavated from the ditches and not as yet thoroughly dried out from the service rendered by the ditches.

As for surface material, in many places it will be found that along or adjacent to the road there are hills or hummocks which contain soil not properly either hardpan or clay, but in many places a combination of each containing considerable metal in the shape of either pebbles or fractured stone. Having obtained the bottom through drainage and the addition of stone so that the sub-base will be practically dry, you may apply 10 inches of the material containing a small amount of metal and by the use of road drags and road hones bring this first into section and next into a smooth, hard surfacing, which will prove satisfactory in all weather for traffic, provided it has constant attendance and is repeated after every rain dragged with the ordinary road drag. The drag removes every slight rut which may be started and does not allow the water to settle through the weak upper surfacing. The maintenance must be not intermittent, but constant. A somewhat slippery upper surface may still be found, in which case it will be necessary to add an inch or two of gravel or sand from section two. This may only require from 3 to 6 yards of gravel surfacing per 100 feet, and while it may be at a considerable distance from the improvement, it will not add materially to the cost.

The surfacing upon such a type of road will require practically 2,000 yards per mile, and if the material is from different banks along the roads the cost will not exceed 20 cents per yard. It is then perfectly feasible over this section to build such a highway, including the raising of the grade from 1 to 2 feet at a cost of not more than the estimated limit of $2,500 per mile.

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*From a paper entitled "Surfaces for Light Volume Mixed Traffic," read at the Fourth American Road Congress, Atlanta, Ga., November 10-14, 1914.

On section two, as before described, there is a problem of grading, rather than of drainage. That is, the soil will readily dispose of water, but the grades must be reduced to a reasonable gradient and with a sandy material some method for compacting the road provided. The first to consider, then, is what shall be the maximum grade.

In this class of construction the writer proceeds backwards, rather than attempting to dictate an absolute gradient. That is, he takes the heaviest grade and sees to which per cent. he can reduce this with a reasonable amount of money, instead of saying arbitrarily that a 4 per cent. grade is the maximum, he figures how much it will cost for a 4 per cent., how much less for a 5 per cent. and what the saving would be, should even a 6 per cent. grade be allowed.

We will say that we may reasonable reduce the grade on this section to 5 per cent. This is established as a maximum and the other grades are brought to this maximum.

There will doubtless be considerable blasting on the large boulders to do on this section in order to properly widen the road, because the ordinary country road has no established width. In cutting the grades it will usually be found that a considerable portion of the material excavated in reducing the grade makes good surface material and almost the entire expense will be the shaping of the roadway and the drainage.

As we have imagined it, however, as the end of this section is approached you will have run through the gravel and into what is practically sand. Here the gravel on the other end will not properly compact or pack so as to make a suitable road surface and practically a sand-clay road must be built. The writer has not had good success with the sand-clay roads, unless he has practically telfordized the same by making the sub-base largely of metal.

In the treatment of this particular part of section two, we might endeavor, from the gravel pits used on the first part of it, to obtain the small boulders sufficient to build the entire bottom of the road to at least 6 inches in thickness of such pebbles. These might be filled with sand up to the top of the metal, then at least three alternating sections of clay and sand put on, repeating until the road is at least 10 inches thick, harrowing each section as it is built up, and seeing that the top surface is of sand rather than of clay. This portion of the section will doubtless cost much more than the sum per mile expended upon the gravel portion, but together they should leave the general average within the limit.

Section three, consisting largely of grade, is almost entirely a drainage proposition and it will be very necessary to practically tap the water coming from the side hill near the surface or originating within the road. It may be found necessary in many instances to run short drains for the express purpose of tapping the water holes, which come up in the road-bed proper, and it will doubtless be necessary on the inside of such a road to lay a side drain the entire length of every grade. A ditch should be dug on the upper side of the road to a depth of at least below frost line, a foot of sand being placed in the bottom and then an open drainage tile laid to as perfect a grade as possible, and the ditch filled in with sand, seems to be the most satisfactory way of cutting off this water.

Shaping the clay road is a comparatively easy matter, as such a road will retain its section and may be practically worked with a road machine and then covered with 2 inches or less of sand and gravel, harrowed in as thoroughly as possible. It is somewhat difficult upon a clay road to get the sand to work into it at first and the farther application during wet weather of at least 2 inches more will ordinarily give such a road a most desirable surface. The only caution is that the sand must not be applied in large quantities at a time, but this surface must be expected to require renewing frequently during the first two years.

We have assumed that we have now come to the ledge and boulder section and that all material must be drawn from a considerable distance to make a satisfactory road. Here, without question, the most feasible plan is to use a macadam roadway. The putting up of a local crusher and the macadam method of construction may facilitate building at a lower cost than would the use of the uncrushed material. Frequently, however, on such sections there is a great difficulty in getting sufficient water to properly flush a waterbound macadam road. The use of large quantities of water may be obviated by the use of bitumen, but this adds to the cost of your road.

Wherever macadam is used the same 21-foot section may be retained, though 15 feet should be the extreme width of the metalling. This will take 2,600 tons per mile of stone, and assuming the use of 2½ gallons of bitumen per square yard, the added cost will be something over $2,000 per mile. If water is fairly available, a waterbound road may be built and one-half gallon per square yard of bitumen applied as a cover coat at a cost of about $650 per mile, which will reduce the cost of the road for light traffic about $1,500 per mile. Unless there is considerable trouble about getting water, therefore, the use of waterbound macadam with the blanket coat is recommended.

The added cost of maintenance upon the macadam road, as compared with the cheaper forms, must also be considered, so that personally we should hesitate about using macadam whenever there is a possibility of using the cheaper surfacing.

Assuming a small apportionment available for the entire mileage needing improvement, the economic question is, what plan should be adopted for the treatment of such a highway? Will this 10 miles be practically completed with the money or will 3 miles of the higher type of roadway be built and the rest left unimproved? This seems to be the attitude adopted by most highway departments. They standardize their plans and specifications and are content with the small mileage of what they are willing to say is the best construction, and they dislike extremely to build for small cost what they term an inferior type of road.

The writer believes this to be a serious economic error and in most sections a road infinitely better than has previously existed may be built at a comparatively small cost to the great betterment of the roads in general and to the great help of the inhabitants of a community.

As far as automobile traffic is concerned, many of the inferior types of road are far more satisfactory to them in general than the highest type. The autoist cares little for a short section of the best possible road if at the end of it he plunges into what he is pleased to call an impassable road for three-quarters of the distance. The writer believes the development of roads in the future will be along the line of more mileage and less cost, and that this is the proper trend of development.

Cost of Maintenance.—Constant continuous maintenance is necessary upon all the types of roads that are built. It is indispensable, however, that upon the surfaces of the cheaper type of roadway the maintenance be both continuous and intelligent.

A road of what may be called natural surfacing, if left for even a week during the summer season without attention, loses all its features of a good road. It must be constantly patrolled, all holes in it which have worn must be filled, all weak spots which develop must be repaired within a few hours after discovery or the road will so rapidly degenerate that it is useless as an "improved."

The higher types of roadway may be left for varying periods of time without attention, and while this results in the end in being a more expensive method of treatment it is only a loss of money. You still have the road which may be repaired, but if you attempt this sort of treatment upon the cheap surface you eventually lose your highway entirely.

My experience is that a patrolman with a horse and cart, an efficient drag or hone, and the willingness to work, will keep in almost perfect condition from 5 to 7 miles of cheaply constructed roadway, at an approximate cost of from $175 to $200 per mile. Given the same mileage of the higher types of road, he will require a helper, a much larger equipment, and if working upon bituminous roads probably not less than $150 per mile for material in the way of bitumen, crushed stone, etc.

The average cost of maintenance upon the higher types of road including the use of a blanket treatment once in two years will not be less than $500 per mile, and in many instances it will greatly exceed this. On the expensive road also you are constantly facing the fact that within a reasonable number of years you must resurface at a cost approximating $6,000 a mile, while upon your cheaper road, if properly patrolled, you will find that the surface material is thicker than it was at the time the road was built, and has been in practically perfect condition during the entire period.

If the dust nuisance upon the cheaper road becomes intolerable it may be alleviated greatly and practically removed by the application of light bituminous oils or tars. The objection of this treatment, however, is the tendency on the part of a patrolman to allow the road to get out of section by neglecting to drag it after every rain, as he does not wish to destroy the skin coating on top, which is left after the treatment. The cost of this treatment adds about $150 per mile to the cost of maintenance and on the whole is not as satisfactory for light travel in its final results as adhering to the use of the natural soil and the regular treatment by dragging.

Road problems may be roughly divided into four subdivisions, and their order of importance is about as follows: Drainage, alignment, grade and surfacing. It is unfortunate that to most people the latter is more important, while relatively it is of far less importance than the other three. The surfacing material is frequently considered paramount and the settling of the question as to whether you have a bituminous road, penetration method or mixing, a concrete road, or a pavement type is the main subject of discussion, and with far more attention given to it than it rightly deserves.

The drainage, alignment and the change of grade are permanent features. The surfacing can never be permanent. I have sometimes wondered whether a bond issue to be paid for by posterity should ever be expended on any feature that is not permanent.

Concededly, surfacing of all kinds will require not only constant maintenance but rebuilding. With the essentials fully attended to, it is surprising how the surfacing may be maintained at a comparatively small cost. I believe that it is as necessary for us to turn our attention to the economic side of the road question as to the scientific. A highway must have an economic road rental, as well as a fixed road maintenance, and wherever the actual cost plus its maintenance exceeds its rental value we are wasting money in building too expensive a road. We must so adjust the scales that our costs are such as to provide a roadway for the traffic at the least possible expense.

PROGRESS ON THE PACIFIC GREAT EASTERN RAILWAY.

In the recent report of Mr. F. C. Gamble, chief engineer of the Department of Public Works, to Hon. Thomas Taylor, Minister of Railways, it is stated that track laying on the Pacific Great Eastern will likely reach the Fraser River at Lillooet, 120 miles from Squamish, early in January, unless work is impeded by exceptionally heavy snow falls. The rails are already laid from Squamish to the Lillooet River, in Pemberton Meadows, a distance of about 58 miles. Thence it will be continued over that river on a temporary bridge to Anderson Creek. This bridge is necessary while the Federal Government is deciding whether the Lillooet River shall be crossed by a movable or fixed span.

Between Lillooet River and Anderson Lake, a distance of about 28 miles, there will be two truss bridges, one over Owl Creek, with 100-foot span, and the other over Birkenhead River, with 125-foot span, besides small trestles. These two streams, however, may be crossed by temporary bridges to hasten the track to Anderson Lake, which it is expected will be reached this month.

The track having reached the latter point, timber for the trestles along the lake, which are for the most part small, will be put into the water and towed to the different sites, and erected ahead of the track. From the south end of Anderson Lake to the Fraser River there will be several small bridges.

Between Squamish and Pemberton Meadows there are 39,877 lineal feet of side tracks and sidings. These are laid in the Squamish yards and at various points up to Pemberton. The track, to within nine miles of Pemberton, is in excellent shape. There are steam shovels at work in the ballast pit near Squamish.

Of interest at this time is the completion, at the Canadian Locomotive Company's works, Kingston, Ont., of two oil-burning locomotives for the new line. Each locomotive, weighing 190,000 pounds without tender, has four driving axles, the driving wheels being 57 inches in diameter. The cylinders are 22 x 28 in. and are operated by Walshaert valve gearing. The steam will have a working pressure of 180 pounds per square inch, the locomotive being equipped with a Schmidt superheater adding about 250 degrees superheat. Other characteristic features of the locomotives are flexible boiler stay bolts, radial buffers between engines and tenders, and turbo-generator set supplying power for head-light and other lights.

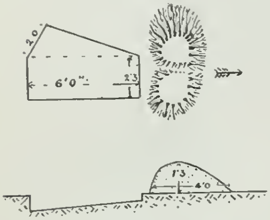
WELLAND CANAL CONSTRUCTION.

Expenditures totalling about $6,000,000 have been made on the Welland Canal work this season (described in *The Canadian Engineer* for November 5th, 1914). The contracts for sections 1, 2, 3 and 5 are reported about one-quarter completed. Together they total over $20,000,000. The sections still to be contracted for will not be let until the existing contracts have advanced considerably further. Nearly 3,000 men are at work.

ENTRENCHMENTS AND OBSTACLES.*

By G. Bertram Hartfree.

IN selecting a site for defensive purposes, natural features are the first consideration, and these will be supplemented by entrenchments; another factor is its advantages to the defenders for counter attacks and to allow a powerful rifle-fire from the position, and it is necessary that the defenders be well screened and protected from the enemy's fire. In deciding the type of entrenchment, time, of course is a great factor, and if this be unlimited, a substantial and well-screened type can be



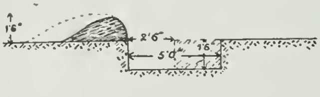


Fig. 1. Fig. 2.
Alternative Shelter Pits for One Man Kneeling.

adopted, but there is the possibility, however, that time will allow only of earthworks of a hasty character; these may be divided into three headings:—

1. Pits for sheltering skirmishers, sentries, etc.

2. Trenches for sheltering the main body of infantrymen and other reserve forces.

3. Pits to give cover for artillery.

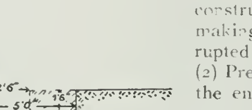
The simplest type is a pit to shelter one man, from which he would fire lying down; in such position the legs are usually inclined to the left. The length of the pit is about 6 feet, and the width 2 feet 3 inches, its depth about 9 inches. Two small adjoining mounds that leave a depression on which the rifle would rest, are constructed with the excavated earth to a height of 15 inches. When making the mounds, as the men's legs would incline to the left, as far as possible, shelter must be made in that direction. With a pick and shovel one man should construct such pit (Fig. 1) in 10 minutes. A better type of pit (Fig. 2) 2 feet 6 inches in width and 18 inches in depth, could be constructed in half an hour; in this a man can kneel when firing; should time allow, an hour's work would make a more comfortable and better protected pit, as shown by the dotted mound and hatching. By connecting adjoining pits, small shelter trenches may be formed, providing for groups of men. The usual allowance in width is 2 feet 6 inches per man. For a man to fire standing, a pit 3 feet in depth is required: this, with the excavated earth, gives a cover of 6 feet; the time taken in excavating and completing this by one man would be one and a half hours. For the foregoing, by commencing a shallower pit, as opportunity occurred, the greater depth could be reached. The ordinary earth mound necessitates a man firing over the top, which leads to an exposure of the head. For better protection loopholing is adopted, and is generally done by the use of sandbags, four of which are required per loophole, two being laid three inches apart as headers, and two resting on the top as stretchers. Fig. 4 shows how a kneeling pit may be developed, the original excavation "A" and embankment "a" may be increased as follows:—

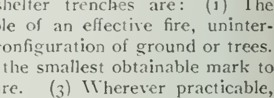
1. For men to stand close to bank, remove space marked "B"; by excavating part marked "C," a seat will be formed. Should a step or kneeling space be required, "B" would remain, and D, C and E would be moved. The breastwork shown on Fig. 5 is a development of the latter, the earth near the firing trench being pushed forward and an outer trench cut on the enemy's side.

The chief points to be considered when constructing shelter trenches are: (1) The making possible of an effective fire, uninterrupted by the configuration of ground or trees. (2) Presenting the smallest obtainable mark to the enemy's fire. (3) Wherever practicable, arrange for drainage. to avoid quagmires in rainy weather. (4) Sand and light earths are better defence than hard earths or plastic clays. (5) A trench should not be made in front of an elevation, particularly if not bullet-absorbing. In respect to the latter, a high sandbank of usual batter would be less disadvantageous to the defenders; but, given a hard rock or wall, on its being struck by a shrapnel shell, the contents would scatter at the rear of the trenches.

Infantry in the second line, either as supports or reserves, are, when possible, protected by natural depressions in the ground. In the absence of these, shrapnel-proof shelters may be requisitioned. These consist of excavations, roofed with timber and covered with earth dressed over to resist bullets and affording no mark to the enemy.

When cover is required for guns there are two





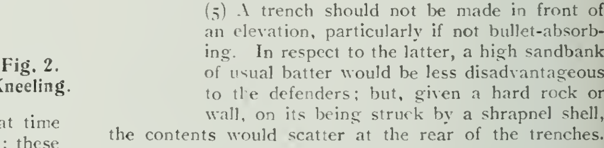


Fig. 3.—Standing Pit. Fig. 4.—The Development of a Kneeling to a Standing Pit. Fig. 5 (below)—Breastworks.

courses open: (1) Construction of an epaulment, or (2) sinking a gun pit. The choice depends on local conditions; given a soft soil with no natural shelter, the latter is preferable, as the excavated earth forms the embankment, and a reduced height above ground is required with less exposure to the enemy's fire. A roughly pitched base to take the wheels would be of advantage. Given a hard soil with natural banks, an epaulment would be preferable, the banks giving, in some part, natural shelter, and their existence requiring less soil for the completed earthwork. The advantage of the latter over the pit is the fact that it can be completed after the gun is in action.

*Read before the Institution of Municipal and County Engineers of Great Britain.

whilst, of necessity, the gun cannot be worked from the pit until its completion. Fig. 7 shows a gun pit which would take one man from 5 to 10 hours to construct, according to the nature of the soil; these pits rarely exceed fifteen inches in depth.

An epaulment is somewhat similar in plan, but varied according to local conditions.

Obstacles.—The strength of a post can be increased by the use of suitable obstacles. In selecting their position a site should be chosen where they can be well hidden from the assailants, but will allow an easy advance on the part of the defenders. No particular materials are specified for this purpose; the most suitable are those that cannot be removed by the ordinary weapons or tools that the attackers would carry. As an obstacle, that to the best of my knowledge is not mentioned in military manuals. I suggest broken bottles, etc., with bottoms set in concrete. Loose straw and leaves saturated with tar would be of advantage against a foe stalking on all fours. Orthodox obstacles include entanglements, pits and palisades; the former consist of wires: these, if set low, are about eighteen inches off the ground, fixed on stout stakes, well driven in and about six feet apart. The wires are twisted around the posts and carried horizontally and diagonally. An entanglement more difficult to negotiate is that with posts four feet above ground, with the wire from the base of one post taken to the top of another, and by crossing the wires a useful defence is made; barbed wire is, of course, preferable to plain.

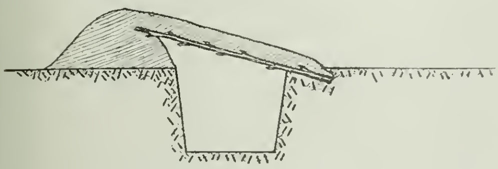


Fig. 6.—Cover for Reserves.

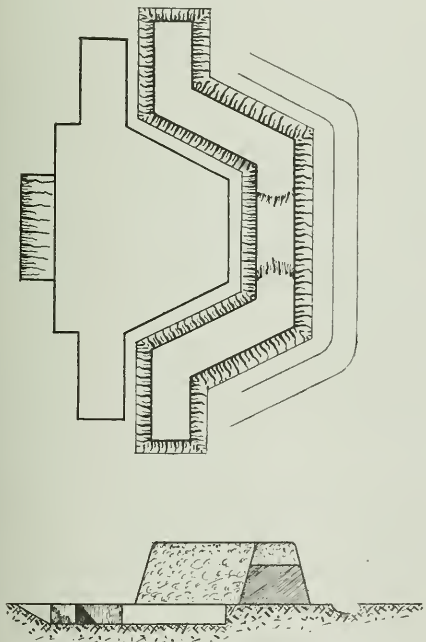


Fig. 7.—Plan and Section of a Gun Pit.

In the absence of wire, pickets with pointed tops, trees, or brushwood fastened with points in the direction of the enemy, will form difficult impediments.

Military pits are planned on lozenge pattern and consist of small holes containing pointed pickets: an entanglement of wire over the surface is of advantage, and further improvement is made by erecting on the enemy's side a glacis, formed of the excavated earth. This should be eighteen inches in height, as near vertical as practicable on the defenders' side, with an easy slope towards the attackers, to facilitate their progress and hide the obstacle until it is reached.

Palisades may be erected in ditches that are controlled by the defenders' fire. A useful material is the pointed form of galvanized iron fencing. In the absence of stock patterns, by the use of an axe on the top edge, the plain pattern can be made very effective.

STREET PAVING METHODS.

The repair of streets and roadways is one of the most important works that come under the direction of the municipal engineer. There are many causes for the defects that are constantly arising with ordinary paving, but perhaps the most prevalent is that the specification, in the first place, was not properly drawn up. Frequently pavements are laid with too weak a base, and cracks develop in all directions. Occasionally the lateral support is far from rigid. Where asphalt surface disintegrates in places it may be found that the decay is due to leakage from gas mains, in which case it is useless to try to patch the surface until things are properly adjusted underneath. The question is becoming pressing as to whether, in the course of the next few years, we shall not have to reconsider all our present methods of roadmaking. It is an open secret that many are investigating the behavior of materials under other methods of laying than those usually employed, under traffic conditions, and a number of interesting experiments have already been carried out. In connection with these it is interesting to recall the work done at Mankato, in Minnesota, a short time ago. First the driveway was narrowed to 30 ft., curbed and guttered, after which it was excavated to the depth of 6 in. and levelled. Five inches of dry crushed limestone, 1½ in. to 2 in. in diameter, was then put on and rolled down with a 10-ton roller. Ordinary tar, brought to the boiling point, was then applied until the whole surface was covered. Then a layer of broken stone of 1 in. to 1¼ in., mixed with coarse gravel, was applied on the surface, in the proportion of three parts of stone to one of gravel. This was first mixed dry on a platform and then thoroughly blended with hot tar, and applied on the surface to a depth of 2 in., and tamped into place to conform with the surface of the street. Dry domestic cement was then applied to the surface, and the street was again rolled, after which the road was heavily sanded and rolled for the last time. The road was allowed to stand for fourteen days before it was thrown open to traffic, and when hardened presented a very fine and somewhat resilient surface, which proved exceptionally durable.

FLOW REGULATION ON THE GRAND RIVER.

THE Grand River Valley, in Ontario, is well noted for its natural production and resources, its manufactures and trade, and its density of population. It is not the earliest settled part of the province, the eastern counties along Lake Ontario claiming that distinction. But with the advent of transportation facilities, the southwestern peninsula progressed and later surpassed the older settlement.

In line with its development, however, has been the partial sacrifice of one of the country's great natural resources—timber growth. Agriculture occasioned heavy invasions into magnificently wooded districts.

Another great natural resource is the perennial, never-failing, precipitation ensuring, with proper husbandry, the continuing productivity of the soil, and ensuring as well stream flow, ground water, water supply as required by large communities, and water power developments.

That the wasteful destruction of forest growth would have produced a marked effect on precipitation, is to be expected, from prevalent ideas of similar conditions elsewhere. That this is not the case, however, but that the effect has been rather on stream flow itself, is brought out in the following article. How the seriousness of the situation has aroused action to prevent damage by spring flood, and what steps are being contemplated to compensate for the axeman's intrusion upon Nature's mode of regulation was brought out in a most interesting manner before the Galt Board of Trade on November 27th, 1914, by W. H. Breithaupt, C.E., Mem. Can. Soc. C.E., Mem. Inst. C.E. Regarding the effect of land denudation, Mr. Breithaupt has this to say:

"Since the beginning of continuous observations, seventy and more years ago, in various parts of the peninsula, (at not many places but at enough to establish the fact), precipitation has remained practically constant, varying somewhat from period to period, but on the whole remaining about the same. Destruction of the great forests has not, as is sometimes erroneously held, diminished rainfall or snowfall. It has, however, caused great change in the flow of streams, the former characteristics of which, moderate floods on snow melting in the spring and well sustained flow throughout the year, having changed to destructive floods, and dwindling, almost disappearing, flow, in the low-water months of the year. The greatest factor of change in the run-off rate of a number of rivers in the Ontario Peninsula has been the drainage of the hundreds of square miles of swamps on the table land of the headwater area.

"With the destruction along the whole course of the river, particularly in the cities and towns along its banks, caused by the spring floods, now almost an annual occurrence, and the small flow of polluted river during the summer months, flood control, and regulation of flow, have become the most important conservation questions immediately concerning us in the Grand River Valley."

These matters were brought to the notice of the Provincial Government at various times. The result has been that for the past two seasons the engineering staff of the Hydro-Electric Power Commission of Ontario has been carrying on an investigation, by topographical survey and by precipitation and stream flow observations preliminary to the adoption of a plan of construction whereby future danger will be minimized. We abstract the following from Mr. Breithaupt's address, concerning the favorable results so far attained and concerning what, illustrated by existing cases of a similar nature, may be expected when the river has been subjected to a system of storage:

There are two main methods of preventing the overflow of a river channel: (1) By making such channel of sufficient cross-section and declivity, by means of walls or dykes on the banks, deepening and removal of obstructions in the channel, cutting off detours and otherwise straightening the channel so as to make it shorter and therefore its declivity greater. (2) By impounding water in excess of the capacity of the channel by means of reservoirs, or by retardation of flow on sufficiently large areas of the watershed by forestation.

When floods on a river are very large as compared to the normal flow the first method requires a relatively large channel, and has the further disadvantages that any improvements benefit only their immediate vicinity and may very detrimentally affect the country further down stream in that the velocity of delivery has been increased, and that the water which might have been held further upstream for sustained flow is wasted. The method of impounding excess waters, on the other hand, benefits the entire river below the reservoir, both in flood control and in sustained flow obtained by the gradual release of the impounded waters.

The St. Lawrence River, with its vast natural regulating basins, the Great Lakes, exemplifies on the largest scale the flow-regulating effect of large impounding reservoirs in the course of the river. On its largest tributary, the Ottawa, greatly increased storage is being obtained by raising the outlets of a number of lakes in the upper part of the watershed of the river.*

The work has been in progress since 1909 and material benefit has already resulted. When completed it will give an increase of low-water flow at the city of Ottawa of from 10,000 to 12,000 cu. ft. per second, bringing the flow for this period to a minimum of somewhat under 40,000 c.f.s. The great benefit of this conservation, in flood relief, equalization of flow and the raising of water level for navigation purposes, will, owing to very favorable natural conditions, be secured at an estimated total cost of less than one million dollars.

In general, the regulation of a river by means of storage reservoirs is more applicable on smaller rivers. On such rivers it has become a well recognized method, and has had numerous successful and highly beneficial applications. I shall here mention two, selected on account of their similarity in many respects to the Grand River regulation scheme, both of them in Germany.

The dam on the Eder River in the principality of Waldeck is 160 ft. high, above foundations, and makes a reservoir with storage capacity of 7,350,000,000 cu. ft., a little over 4½ sq. miles in area. The drainage area above the dam is 542 sq. miles, of which 40% is wooded. Average rainfall on the drainage area is 33 in. in the year. With only 10% of the capacity of the reservoir held as reserve the minimum flow is six times what it had been. The total cost of this undertaking was $4,902,380, of which $2,142,850 was for land and damages. Several small villages and many farms are flooded by the reservoir. One main purpose, beside flood prevention, was the development of water power. The large expenditure has already been found to be an excellent investment.

The largest dam in Europe is on the Bober River, a tributary of the Oder, and was completed in November, 1912. In keeping with its importance as an economic

*This storage on the Upper Ottawa was described in August 7, 1913, and December 4, 1913, issues of *The Canadian Engineer*.

work it was opened with great ceremony in presence of the Emperor. The contributary drainage area, mountainous and steep, with quick run-off, is 467 sq. miles, from which the maximum recorded discharge, in July, 1897, was 42,360 c.f.s., giving a very destructive flood which was the immediate cause of the building of the dam. In comparison to this discharge, that of the Grand River in Galt, from a contributary drainage area nearly three times as large, reached a maximum of between 30,000 and 35,000 c.f.s. on the evening of April 7th, 1912. The minimum flow of the Bober at the dam site is 53 c.f.s. The capacity of the reservoir is 1,765,000,000 cu. ft., large enough to impound the damaging part of the flood, the capacity of the lower river channel only being allowed to pass the dam. Owing to short duration of the flood flow, 60% of the capacity of the reservoir can be retained and used for water power development at the dam and for increase of flow downstream. The dam is 203 ft. high above foundations, and 918 ft. long and 23 ft. wide on the crest. It is a solid masonry structure. With the great depth of water in the reservoir its surface area is a little under one square mile when full. The cost of the dam was $1,416,000, and of land and land damages $576,000, total $1,992,000, of which the State of Prussia paid four-fifths and the province of Silesia one-fifth.

To make flow regulation of a river economically practicable by storage it is necessary that a natural storage basin, or basins, the fewer used for the required capacity the more economical, should exist in the course of the stream, with enough contributary drainage area to give the volume of water necessary to fulfil the requirements of regulation; enough that the impounding of the volume of water coming from it will materially lessen the volume further down stream, and enough that the water so impounded will, on being released at a fixed rate, give increase of flow down stream for a long enough period.

On the Grand River it has been sufficiently demonstrated that if the flood flow of the upper main river, extending to about the north line of the township of Waterloo, and the flood flow of the Conestogo tributary, can be held, in main part, the problem of prevention of destructive floods in the lower river will be solved. Let us see what this would imply. In the great flood of April 7th and 8th, 1912, the approximate maximum discharges, continuing at maximum only for short times and destructively high for two days at most at any place were: At Elora, being the bulk of the main upper river, 13,000 c.f.s.; at St. Jacobs, practically the whole of the Conestogo River, 12,300; at Bridgeport, 4 miles below the Conestogo outlet, 24,000; at Galt, 33,000; at Brantford, 51,000. It is clear that if 15,000 cu. ft. per second of flow of the upper discharge, including the Conestogo, could have been held back for two days the lower river would have remained within its normal channel.

The Hydro-Electric Power Commission began its work on the Grand River in the fall of 1912 with a reconnaissance survey extending from the outlet at Lake Erie to the headwaters of the river and also up all the main tributaries to their headwaters. This survey disclosed three sites on the main river practicable for reservoirs of considerable capacity, the largest one below Elora; two sites on the Conestogo River of fair capacity; two on the Speed River not large enough to be of material benefit; one on the Nith with fair capacity, and one on Whiteman's Creek. Levels were carried the length of the survey and bench marks established, mostly on bridge piers and abutments as far up as Belwood on the main river, and also on the Speed and on the Nith. Eighteen gauges were set, on the main river and tributaries. One in Galt is on the easterly pier of Concession St. bridge; its zero is 851 ft. above sea level. There is also one at Kerr St. bridge, Galt Creek.

Discharge observations began with July, 1913, and as the spring flood this year was an exceptionally light one no destructive flood discharge has yet been gauged by the Commission. Discharges are recorded for five stations on the main river, one on the Nith, two on the Speed, one on the Conestogo, one on Fairchild's Creek, one on Boston Creek, and one on Galt Creek at Kerr St. bridge.

Detailed topographical surveys of the larger reservoir sites have been the work of this year and it is here that important favorable conditions have been found. The largest practicable basin is on the main river in Pilkington Township, Wellington County, extending from about the southerly boundary line of the township, the northerly boundary of Waterloo County, into the gorge below Elora.

The general conformation along the river from the Canadian Pacific Railway bridge at West Montrose up shows a fairly straight, narrow valley, 2,500 to 3,000 ft. in width, with steep sides, about alike, for several miles, and then expanding into a wide basin, which again narrows toward Elora. Contours were established at 10-foot intervals and plotted on a large scale map. Two dam locations were considered, No. 1 dam some distance down the valley described, and No. 2 dam at its entrance at the neck of the wide basin. No. 1 dam gives considerably the larger capacity, 2,618,563,000 cu. ft., as compared to No. 2, 1,920,422,000 cu. ft. The elevation of the river bed at No. 1 dam is 1,065, and water level elevation for the capacity stated is 1,150 ft. Foundation investigations for the dam have not yet been made, but as limestone is exposed a little further upstream and is underlying at the site it is expected that a satisfactory foundation will be practicable. Allowing for depth to foundation and for height of crest above highest water the height of the dam will be 100 ft., or somewhat more, at centre. Its length will be approximately 2,800 ft. The area of the surface of the reservoir when filled to 1,150 ft. elevation will be almost exactly 2½ sq. miles; allowing for marginal land a total of about 2¾ sq. miles, 1,760 acres would be required. A large part of this land is stream bed or subject to overflow, the rest good farm land, including a number of farm steads with their buildings. Two roads and a bridge would have to be relocated. The mean depth of the reservoir when full would be 36.9 ft., maximum depth 85 ft. Assuming the water level not to fall below elevation 1,080 the dischargeable capacity of the reservoir would be 2,592,282,000 cu. ft., in round numbers 2,600,000,000.

The cost of this reservoir cannot yet be estimated with any close approximation. Assuming $75 per acre as an average for the total 1,760 acres we get for this item $132,000. The cost of the dam is as yet indefinite, but if the whole project can be carried out for $1,000,000, as now seems reasonable to expect, or even $1,500,000, it will well repay its cost.

The drainage area to this reservoir site is approximately 480 sq. miles. Assuming an annual precipitation of from 35 to 38 inches and a run-off of 1 ft., the annual run-off would suffice to fill the reservoir five times. The 1912 flood flow in Elora, 13,000 c.f.s., would take 55¼ hours to fill the capacity of 2,600,000,000 cu. ft. A considerable stream, the Irvin River, comes in just below Elora. This, with a smaller stream, gives over one-seventh of the drainage area of 480 sq. miles considered. Assuming the Elora discharge to be correspondingly in-

creased, to 15,000 c.f.s., we get exactly two days, 48 hours, of maximum flood flow containable in the reservoir, and this would be the maximum relief afforded for the length of the lower river from this one reservoir, a relief that would reduce the 1913 maximum two days' flow in Galt by more than half.

It is, however, very desirable to also control the flood flow coming from the Conestogo. On this tributary the results have not yet been so fully worked out as for the Pilkington basin. No such capacity as that is found practicable on the Conestogo, but there is one site, fairly upstream, with drainage area of not over 250 sq. miles (the drainage area to St. Jacobs is 312 sq. miles) where it is approximately estimated that a capacity of one billion cu. ft. can be obtained. This, together with the No. 2 Pilkington dam (smaller than No. 1) would give better flood control in the lower river, in that a much larger volume could be held back, even if for shorter time. In this manner a volume approximating 20,000 c.f.s., the combined flow of both main river and Conestogo tributary, could be held back for 24 hours.

As to maintenance of flow for the low-water months, 2.6 billion cu. ft. of water would give a continuous flow of 300 cu. ft. per second for three months and ten days. In that period rainfall at various times could be expected, making up not alone for evaporation in the reservoir but also contributing to flow. On the other hand, evaporation appears, as far as observations of stream flow have gone, to have large diminishing effect on run-off, in the Grand River watershed.

At Belwood the mean discharge for the months of August and September, 1913, was only 5 c.f.s.; at Conestogo, drainage area 538 sq. miles, 24½ c.f.s.; while at Eugenia Falls, on the Beaver River, on the steep slope to Georgian Bay on the north side of the table land, the main discharge for the same time, with only 74 sq. miles of drainage area, was 30½ c.f.s., a very remarkable difference, due to two main conditions, the much greater declivity of the Beaver drainage area, and the fact that it contains swamps and is otherwise still largely wooded.

A reservoir above Elora and Fergus is very desirable in the complete scheme. At Belwood the drainage area is 270 sq. miles and the valley deep and apparently well defined. Investigations so far have not given a sufficiently favorable reservoir site.

One feature greatly simplifying the problem on the Grand River is that there is only one large flood in the year, in the spring on snow melting. The great floods in Ohio and Indiana last year were also in the spring, in March, but were caused by rainfall, almost wholly.

There was rainfall of 5.31 in. in 47 hours, 3 in. in 20 hours after the first saturation. Three inches of run-off in the drainage area of Galt would produce 9,500,000,000 cu. ft. of water to pass which, even in 36 hours, would mean a continuous, uninterrupted flow of 40,000 cu. ft. per second, greater than any maximum that has occurred here. Waves lasting for hours only would much exceed even this discharge. There is no record of any such discharge in the Grand River valley. At the present day it would mean destruction of property on an unprecedented scale. Precipitation in the central parts of the United States and Canada is largely from the Gulf of Mexico, as this was. It spread over a large area in Ohio and Indiana. Why did it stop at Ohio? The cool belt of equable temperature over the Great Lakes, around the Ontario Peninsula is, no doubt, a barrier against extreme meteorological disturbances.

It may be accepted as now established that flow regulation on the Grand River, control of destructive floods and maintenance of flow in low-water period, by impounding surplus waters, whether in one or more reservoirs, is economically practicable.

SAFE LOADS FOR ROPES AND CHAINS.

The accompanying table shows the safe loads which can be carried by wire rope, crane chain and manila rope of various sizes, when used in different positions and combinations. This very useful information has been compiled by the National Founders' Association and published as a part of a safety bulletin recently issued. The following are from among the valuable pointers the bulletin contains:

Chain hooks and similar parts should slowly bend if overloaded and thus give warning of their unsafe condition. They should therefore be well annealed, and never tempered or hardened. A brittle part will snap outright and drop the load.

It is clear that hoisting appliances should be suitably designed and well made. It is yet more important that their use be carefully and intelligently supervised and their original strength maintained. There is evidently not so much danger when handling unusually heavy loads, for such operations are, as a rule, under the care of the most capable men, who anticipate the extra risk by careful preparation. Hoisting accidents more frequently occur when ordinary loads are being handled by ordinary men, and when the usual facilities are either too light, wrongly employed, or weakened by wear or use.

It is of first importance that men using hoisting accessories should know the strength of the same. It is not sufficient to know the size, unless the grade is also known. While 1,500 lb. may be a safe load for a single sling made of ⅜-in. plow steel wire rope, such a load would be excessive for an iron wire rope sling of the same diameter. This wide range of strength also occurs in different grades of chains and other accessories, but the difference is not readily apparent. It is therefore dangerous to provide several grades of slings and hooks in the same shop. Furthermore, a new workman, fresh from a shop in which only the strongest slings and hooks are employed, is liable to assume that the appliances in the new shop are equally strong. The safety of workmen, therefore, requires that all slings of equal size should be of equal strength, and of maximum strength, and that other details are proportionately strong.

While workmen who are accustomed to the use of slings acquire, by long experience, a valuable knowledge of the strength of chains and ropes under varying conditions, this should not be left to guesswork. It is advisable to post in conspicuous places in the shop, especially at the chain racks, and, where possible, at the point of operation of each crane, a chart showing the loads which can be safely supported by slings of various sizes, whether used normally or in a manner that decreases their lifting capacity. From a study of satisfactory crane practice in various large plants, a chart of safe loads has been compiled, which is published herewith. The loads recommended in this chart are more conservative than those usually specified, because it is intended to recognize the possible existence of slight, unobserved weaknesses in slings and the liability of excessive strains which may be applied to slings through misjudgment or accident.

It will be noted that the safe loads shown upon this chart are based upon the use of 6 by 19 or 6 by 37 plow steel wire rope; the best grade of wrought iron, handmade chain; and four-strand long fibre manila rope. Here

again the advantage of standardizing the grades of materials used for hoisting purposes is an advantage; otherwise the chart would be misleading.

Under no condition should hoisting appliances which are defective or unsafe be allowed to remain within the reach of the workmen. By carelessness or mistake, these may be used in place of perfect ones with serious results in the shape of an accident ensuing. A defective chain, hook, eyebolt, ring or other hoisting appliance should be removed from the shop on the instant of its discovery. In addition, they should be so damaged, if they are impossible of repair, that there is no possibility of a workman using them by mistake. One of the reasons which may tend to prevent enforcement of this rule, is an inadequate supply of slings and other accessories. Unless there are

SAFE LOADS FOR ROPES AND CHAINS
(IN POUNDS)
Prepared by National Founders' Association

CAUTION: When handling molten metal, wire ropes and chains should be 25% stronger than indicated in table.

NOTE. The safe loads in table are for each SINGLE rope or chain. When used double or in other multiples the loads may be increased proportionately.	Dia.	Cir.	When used straight	When used at 60° angle	When used at 45° angle	When used at 60° angle
PLOW STEEL WIRE ROPE	3/8"		1,500	1,275	1,050	750
	1/2		2,400	2,050	1,700	1,200
(6 strands of 19 or 37 wires.)	5/8		4,000	3,400	2,800	2,000
	3/4		6,000	5,100	4,200	3,000
If crucible steel rope is used reduce loads one-fifth.	7/8		8,000	6,800	5,600	4,000
	1		10,000	8,500	7,000	5,000
	1 1/8		13,000	11,000	9,000	6,500
	1 1/4		16,000	13,500	11,000	8,000
	1 3/8		19,000	16,000	13,000	9,500
	1 1/2		22,000	19,000	16,000	11,000
CRANE CHAIN	Dia. of iron					
	1/4"		600	500	425	300
(Best Grade of Wrought Iron, Hand-made, Tested, Short Link Chain.)	3/8		1,200	1,025	850	600
	1/2		2,400	2,050	1,700	1,200
	5/8		4,000	3,400	2,800	2,000
	3/4		5,500	4,700	3,900	2,750
	7/8		7,500	6,400	5,200	3,700
	1		9,500	8,000	6,600	4,700
	1 1/8		12,000	10,200	8,400	6,000
	1 1/4		15,000	12,750	10,500	7,500
	1 3/8		22,000	19,000	16,000	11,000
MANILA ROPE	3/8"	1"	120	100	85	60
	1/2	1 1/2	250	210	175	125
(Best Long Fibre Grade.)	5/8	2	360	300	250	180
	3/4	2 1/4	520	440	360	260
	7/8	2 3/4	620	520	420	300
	1	3	750	625	525	375
	1 1/8	3 1/2	1,000	850	700	500
	1 1/4	3 3/4	1,200	1,025	850	600
	1 1/2	4 1/2	1,600	1,350	1,100	800
	1 3/4	5 1/2	2,100	1,800	1,500	1,050
	2	6	2,800	2,400	2,000	1,400
	2 1/2	7 1/2	4,000	3,400	2,800	2,000
	3	9	6,000	5,100	4,200	3,000

plenty of spare appliances, there may be hesitation in removing a sling from service for the purpose of repairs. It may be retained in use until a more convenient season, but during this interval it may become subjected to a greater strain than it can withstand in its weakened condition, and an accident with possible resultant loss of life may take place.

In the use of chain slings, the workman should be cautioned against striking heavy blows either upon the chain or the hooks to force them into position on the load. These blows are liable to injure the chain and cause a weakness, which will result in its eventual failure. Where multipart slings are used and it is necessary to equalize the length of each part, other material than cast iron should be used for insertion between the links of the chain. Cast iron pieces will break under load and the failure will cause a sudden shock on the chain links which may break or permanently injure it. In the use of wire rope slings, kinks must be avoided. These acutely bend the wires, which bends are suddenly straightened out under load. An excessive strain thereby comes upon the sling and breaks it.

INERTIA EFFECTS IN PIPE-LINES.*

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An extended and detailed study of the conditions to be found in pipes conveying water, when the velocity of flow is changed, has led to the conclusion that there has not been an adequate recognition of the importance of considering the elasticity of both the water and the pipe walls. It has become clear that only by such consideration can correct results be obtained.

It is commonly admitted that the rapidly moving pressure waves set up, when a valve is opened or closed, are annoying and, when excessive, must be taken care of by relief valves, but it is claimed that they have no place in those greater and longer movements which accompany velocity changes. A formula which is often used to calculate these effects ignores the compressibility of the water and the elasticity of the pipe material. It is the purpose of this article to show clearly that this formula is absolutely and unequivocally wrong, has no foundation in fact, and must lead to erroneous results.

At the foundation of all these phenomena is gravity, the manifestation of nature which gives to bodies that quality called weight, which when opposed produces pressure and when unopposed produces movement. Should the opposition decrease, the pressure will decrease and the velocity increase, and vice versâ. This is universal and applies to all ponderable bodies. Such influences as friction, which cause a loss of energy, will modify the results in accordance with their magnitude.

Inertia is that quality of bodies which tends to keep them in a given state of rest or motion unless acted on by some force. A body in motion has energy in proportion to its weight and to the square of its velocity. It is evident, therefore, that to increase the velocity of a body it is necessary to put energy into it, and to decrease it, energy must be taken from it. This act is called overcoming the inertia of a body. It is furthermore true that with a given change of velocity, the amount of energy put in when accelerating will be the same as that taken out when retarding. In other words, acceleration and retardation differ only in direction, the energy change being the same with any given velocity change.

The above remarks are elementary in nature and are introduced solely for the purpose of laying a foundation for what follows.

Consider a pipe-line filled with water under pressure and provided with a valve at the lower end. When the valve is in a closed position the water is compressed and the pipe distended in proportion to the pressure. In this case gravity, being opposed, produces pressure. On

*From Western Engineering, August, 1914.

opening the valve the opposition to gravity decreases and movement results. This commences at once, and the velocity at a point behind the valve will be in proportion to the fall in pressure at that point. Whether a gauge located there will correctly indicate the fall in pressure will depend upon its accuracy and sensitiveness and upon the manner in which it is attached to the pipe. In this case the energy which must be put into the water to increase its velocity comes from the water itself and from the pipe walls, which are now under less stress, and which have given up a portion of the energy stored in them. This involves a change from potential to kinetic energy.

On the other hand, when the valve is moved in a closing direction, the opposition to gravity is increased, the velocity decreases and the pressure increases; the energy given up by the water as a moving body is stored in the water and pipe walls, the one being compressed and the other distended.

In both instances an unstable condition is set up, as in the first case the pressure is much below that due to the head, and in the latter much higher. The former persists until the energy taken can be restored, which occurs on the return of the wave from the reservoir, and the latter until the excess stored can be dissipated. Equal velocity changes are accompanied by equal pressure changes whether the water be accelerated or retarded.

The changes which commence at the valve are followed by changes along the pipe-line, pressure waves traversing the pipe at velocities dependent upon the material of the pipe walls and the ratio of wall thickness to diameter.

In a previous article formulæ and diagrams were given to determine the velocity of wave propagation and the maximum ram pressure attained under any given set of conditions, and reference is made thereto for these particulars.

It is to be noted that if, in a given case, a decrease in velocity of flow of 1 ft. per second is accompanied by a ram pressure of 50 lb., a like increase in velocity will be accompanied by a fall in pressure of 50 pounds.

The formula commonly used for calculating the inertia effects of velocity changes is

$$Ha = \frac{L\,v}{g\,t} \text{ in which}$$

Ha = accelerating or retarding head in feet.
L = length of pipe in feet.
v = velocity change, feet per second.
t = time of change, in seconds.
g = 32.2 feet per second.

This considers that the pipe is rigid and the water incompressible. It necessarily includes, as a condition, that, in a uniform pipe, all the water shall have the same velocity at the same time; that any change in velocity at the lower end shall be accompanied simultaneously by the same changes throughout. This is indicated by the inclusion of L, the length of the pipe. As a matter of fact such a condition has been shown, theoretically and experimentally, to be impossible.

The most extensive and thorough experiments along these lines were made in 1897 and 1898, in Moscow, Russia, by three engineers, working under the directions of N. Simin, manager of the city waterworks. The results were worked up by N. Joukowsky, in 1898 and published in 1900.

These show conclusively that changes initiated at the valve produce changes along the pipe after a time interval dependent upon the distance and the velocity of wave propagation, and they prove, in a very satisfactory manner, the formulæ which have been developed by theoretical means.

To bring out clearly the difference in results between the correct elastic theory and the incorrect rigid formula, the following table has been prepared. It applies to a steel pipe, 24 in. diameter, ¼-in. wall, and having lengths as listed. The velocity of wave propagation is 3,370 ft. per second.

Pipe = 1,000 ft. long.

Time of gate closing, sec.	0.00	0.02	0.04	0.10	0.30	0.45	0.60
Pressure, rigid formula	00	675	337	135	45	30	22
Pounds, elastic formula	45	45	45	45	45	45	45

Pipe = 10,000 feet long.

Time of gate closing, seconds	0.00	0.02	0.10	0.30	1.00	3.00	4.00	5.00	6.00
Pressure, rigid formula	00	6750	1350	450	135	45	34	27	22
Lb., elastic formula	45	45	45	45	45	45	45	45	45

There are several interesting facts brought out in the table. In the rigid formula the pipe length has a decided influence on the calculated result, while in the elastic, it has none whatever as far as the amount of pressure is concerned, but it does control the duration of this pressure. This has been amply proved by experiment. In the rigid formula the time of gate movement has an inverse proportionate effect upon the calculated pressure, while in the elastic, within certain limits, it has no effect. There is this fact to be noted in this connection, that the rigid formula requires that the pressure shall instantly rise to the figure given and remain there during the entire closing movement of the gate, and that the elastic indicates that the rise will be gradual and in proportion to the decrease of velocity. Experiments have shown that the former is not true and that the latter is true.

The pressures agree for a closing time equal to the time required for the wave to reach the reservoir, but with the non-elastic formula, this pressure must be considered to have existed during the entire time, while in the elastic, the maximum is reached only at the end of the period. To obtain this pressure throughout the entire period, using the elastic formulæ, the gate would have to be closed instantly. With less closing time than that mentioned above the non-elastic formula gives results which are excessive, and with greater results which are too low.

There is nothing in the non-elastic formula to account for that lagging effect which is so well known and which causes recurring waves. These are perfectly accounted for by the elastic theory, and, under proper conditions, can be predetermined.

At the limits given in the table the pressures given by the elastic formulæ commence to fall off, decreasing with increase of closing time. It is readily seen that with long conduits a great variance in results will be found, and as the elastic formulæ are based on actual conditions fixed by natural laws, a choice should not be difficult to make.

The table is based on a velocity of only 1 ft. per second. For changes of 5 to 10 ft. per second the differences would be much increased, as the ram pressures in both cases increase in proportion to the velocity change.

It is evident that the non-elastic formula is based on certain assumptions, namely, that water is incompressible and that the pipe walls are rigid, which are not true; therefore the results obtained by its use cannot be correct. How great the variation will be will depend, as shown in the table, upon the time taken for the velocity change.

COMPUTING CROSS-SECTION AREAS.

THE co-ordinate method of determining areas is not well understood, probably because of its simplicity. Were it to involve the use of higher mathematics every engineer would likely be more or less familiar with it.

Distances measured parallel to $X X$ are usually called abscissas, and those parallel to $Y Y$, ordinates. (See Fig. 1.)

The co-ordinates of any known point are usually computed from the co-ordinates of some other point to which the unknown point is tied by an angle and distance. The difference in co-ordinates between the known and unknown points will be obtained thus:

Difference in X = distance × sin. azimuth angle.

Difference in Y = distance × cos. azimuth angle.

Sometimes the unknown point is located by angles from two other points, in which case the distance between the two points whose co-ordinates are known can be computed and then the distance from one of the known points to the unknown point.

To Determine the Area of by Rectangular Co-ordinates.—The area of the figure 1, 2, 3, 4 (Fig. 1) is equal to the trapezoids:

$(a, 1, 2, b)$ + $(b, 2, 3, c)$ — $(a, 1, 4, d)$ — $(d, 4, 3, c)$.

Expressed as an equation in terms of the co-ordinates the area is:

$$1, 2, 3, 4 = (y_1 - y_2)\frac{x_1 + x_2}{2} + (y_2 - y_3)\frac{x_2 + x_3}{2}$$

$$- (y_4 - y_3)\frac{x_4 + x_3}{2} - (y_1 - y_4)\frac{x_1 + x_4}{2} \quad - \quad - \quad (1)$$

$$= \tfrac{1}{2}\left[y_1(x_2 - x_4) + y_2(x_3 - x_1) + y_3(x_4 - x_2) + y_4(x_1 - x_3)\right] \quad (2)$$

From this equation is derived the following rule for obtaining the area from the co-ordinates of its corners:

(1) Number the corners consecutively.

(2) Multiply each abscissa (or ordinate) by the difference between the following and the preceding ordinates (or abscissas), always subtracting the following from the preceding (or always subtracting the preceding from the following), and take half the sum of the products.

The adoption of this method of computing railway cross-sections or other earth bodies is quite simple. A cross-section is considered merely as an area, the co-ordinates of all corners of which are known—the cuts or fills being looked upon as ordinates, and expressed in terms of Y, the distance out from the centre being looked upon as abscissæ and expressed in terms of X, and the area being A. The general formula for any conceivable shape of section (Fig. 2) would be:

$$A = \tfrac{1}{2}\, y_0 \left[(x_1 - x_n) + y_1(x_2 - x_0) + y_2(x_3 - x_1) + y_3(x_4 - x_2) + y_4(x_5 - x_3) + y_5(x_6 - x_4) + y_6(x_7 - x_5) + y_7(x_n - x_6) + y_n(x_0 - x_7)\right].$$

The application of this formula is by no means so difficult as the formidable appearance of the algebraic or word statement would indicate. In making use of this formula (which is adopted to the computation of any conceivable shape of area) it may be necessary for one in figuring the first few sections to draw rough sketches of the sections in order to make sure he is not confusing the order of the points, but a very little experience soon enables him to compute the areas from the cross-section notes directly without this help. The formula may be taught in a few minutes to men with scarcely a grammar school education, while well educated engineers are frequently obliged to plot each section, and then laboriously either break it up into triangles or run the planimeters over it to find in the end only an approximate area.

The formula is not an approximation, as slope and other formulas are. It is mathematically exact as shown in Fig. 1, and is absolutely general. Its application to the

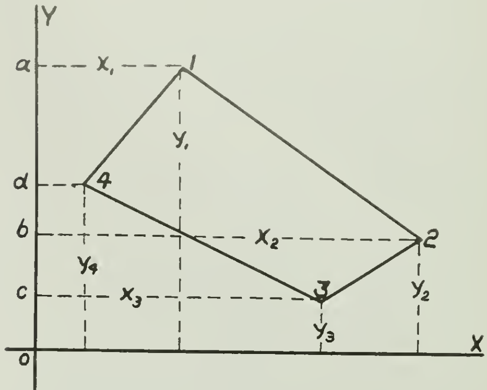


Fig. 1.

simpler sections shows up, as well as the more difficult "three-level" section. The following concrete directions should be followed:—

Begin at any point on the section and proceed in either direction (clockwise or counter-clockwise), multiplying each cut (or fill) in its order by the horizontal distance between the point just preceding and the point just succeeding. In cases where one passes to the right in measuring the horizontal distance from the preceding to the succeeding point the product obtained by multiplying this distance by the cut (or fill) at the intermediate point is of one sign and in cases where one passes to the left the product is of the opposite sign. Take one-half the difference between the sums of the products of opposite signs and the result is the area of the section.

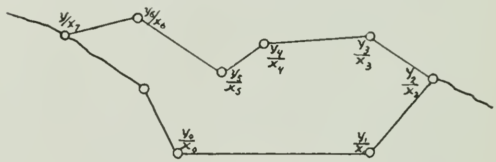


Fig. 2.

A peculiarity of this formula is that while it is absolutely general, its application to the simpler sections shows immediately the shortest possible way of computing the areas. Thus, in a side cut where only the slope stake reading and the intersection of the earth surface with the grade line are taken, the area is a simple triangle and application of the formula to the computation of the area would seem to require three multiplications. But one factor in each of two of these multiplications is zero because the points are on the grade line and the cut (or fill) equal to zero, and it is therefore necessary to perform only one multiplication and take half the product. Also in the case of the so-called "three-point section," or "three-level section," which is really a five-point section,

two multiplications are similarly eliminated and two more (the outside slope points) can be worked together by first taking the sum of these cuts (or fills) and then multiplying by one-half the roadbed widths. This fact is apparent at once, because inspection shows that in every section each of the outside cuts (or fills) will be multiplied by half the roadbed width. Many more useful and interesting features of the application of the formula appear as one extends its use.

The data obtained from field notes are usually in the form of cross-sections which are taken at right angles to some general line of the construction, thereby dividing the earthwork into prismoidal solids with their bases parallel and their sides either plane or warped surfaces. The

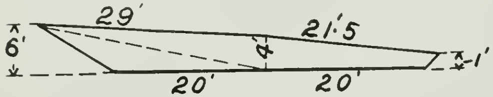


Fig. 3.

bases of the solids are the cross-sections which are obtained by taking sections of trench excavation or of road construction.

End Area Formula.—The simplest method of computing the volume of a prismoidal solid is to average the areas of the two bases and multiply by the distance between them, which, expressed as a formula, is

$$v = \frac{A_1 + A_2}{2} \times l \quad \text{(End area formula).}$$

in which A_1 and A_2 are the areas of the two end bases and l is the distance between them. This method is used to a very great extent throughout the country, although it does not give sufficiently accurate results for certain classes of work.

Prismoidal Formula. — The correct volume of a prismoid is expressed by

$$\text{Volume} = \frac{l}{6}(A_1 + 4A_m + A_2)$$

in which l is the distance between the two bases, A_1 and A_2; and A_m is the "middle area"; i.e., the area half-way between the two bases, which is obtained by averaging the corresponding dimensions of the two end areas, A_1 and A_2; it should not be taken as the mean of A_1 and A_2.

The end areas can easily be computed by dividing them into triangles, as shown in Fig. 3, the area of which can be found readily from the dimensions given in the field notes.

$$\text{Notes of section:} \quad \frac{29.0}{+6.0} \quad +4.0 \quad \frac{21.5}{+1.0}$$

$$\text{Area} = \frac{4 \times (21.5 + 29)}{2} \quad \frac{20 \times (1 + 6)}{2}$$

$$= 2 \times 50.5 + 10 \times 7 = 171.$$

It is also the custom with some surveyors to plot each section carefully to scale and to obtain its area by use of the planimeter. This is probably the most practical method when the sections are very irregular since the field work does not warrant the use of very accurate methods.

There are several other methods employed in computing earthwork but the above are by far the most common.

Rough Estimates.—Rough estimates of the quantity of earthwork are often required for preliminary estimates of the cost of construction or for monthly estimates of the amount of work done. For preliminary estimates of road construction, very frequently the notes of alignment and the profile of the centre line are the only information at hand. From this profile the centre cuts or fills can be obtained, and the cross-sections can be assumed to be level sections and computed by the end area method. The slight errors resulting will be corrected in the final estimate.

In obtaining the required data from which to make an approximate estimate of the quantity of earthwork, the engineer has an opportunity to exercise his judgment extensively. Rough estimates do not, as a rule, call for a large amount of field work. It is important that as few measurements as possible should be taken and that these should also be at the proper places to give complete data and to allow simple computations. Too often engineers, as soon as they arrive on the work and before making a study of their problems, begin to take measurements, consequently they return to the office after hours of hard work with a mass of figures from which it will take several more hours to compute the quantities. A few moments' thought given to the choosing of the proper measurements to be taken in the field would give data which could be computed in a few minutes by use of the slide rule, affording results sufficiently accurate for rough estimates.

FAILURE OF TEMPORARY DAM.

The new power plant of the Ottawa and Hull Power and Manufacturing Company, which is being constructed at the Chaudiere Falls, has received a setback owing to the breaking of a temporary dam while excavation work was in progress. Foundation work includes a large amount of rock excavation. The lumber mills of J. R. Booth & Company are close by, and a temporary dam, which had been constructed of earth and cinders, was built on the edge of the power site nearest the mills. It is thought that owing to a sudden rising of water in the river and a simultaneous starting of the mills, a strong eddy was produced near the temporary structure. It was of such duration that before the water had subsided the cinder embankment had been worn away and the excavation flooded.

A cofferdam will be constructed without delay and the flooded portion pumped out.

YORK COUNTY (ONT.) ROAD WORK IN 1914.

At the November session of the York County Council, just closed, Mr. E. A. James, chief engineer of the York Highway Commission, presented the commission's report.

The commission was organized in 1911, with instructions to build 110 miles of road in the southern part of York County. During 1914 they constructed some 20 miles of roads, including bridges, at a cost of about $90,000. This makes completed to date some 80 miles of road at an expenditure, including bridges, of $500,000. The type of road includes gravel, water-bound macadam, tar-bound macadam, concrete and brick.

A new $300,000 post office was opened last week at Lethbridge, Alta.

Editorial

ONTARIO WORKMEN'S COMPENSATION ACT

The new Workmen's Compensation Act, passed at the last session of the Ontario Government, comes into effect on January 1st, 1915. Those who have given the matter serious consideration have not reasonable grounds to find fault with this advanced legislation.

It has taken a long time for the province to make proper provision for workmen injured by industrial accidents and their dependants. Under the old law the employer of labor had many defences which enabled him to resist, if desired, claims for compensation made by injured employees. This was the fault of the laws on the statute books relating to the liability of an employer for accidents to his employees. Under the new law, these defences are abolished. The fact of the injury alone will entitle an injured workman or his dependants to certain compensation provided by the act. The Ontario government, therefore, has shown a progressive spirit in enacting a new law to take the place of the obsolete one that has been in operation in that province since 1885.

But *The Canadian Engineer* cannot see eye to eye with the government regarding the plans they have adopted for the administration of the new act. Based on the German system, the new act has taken away the liberty of the employer in schedule known as number 1, preventing him buying his protection, or insuring, in the cheapest market. He is compelled under the grouping system to subscribe to an accident fund and is assessed with other employers of labor in the same group, according to the requirements of the case, in respect to current payments as well as deferred payments, as called for under the act. Great powers are given the commissioners in the matter of making assessments and transferring employers from one group to another as they may deem advisable. Indeed, the commissioners have the power at any time to take the employer out of Schedule I. and transfer him to Schedule II. or to put him beyond the scope of the act altogether. Schedule II. deals with industries, the employers in connection with which are individually liable to pay the compensation.

When an employer is taken out of Schedule I., which schedule subscribes to the accident fund, and is placed in Schedule II., the individual liability obtains. That is to say, he still comes under the provisions of the act, but is compelled either to carry his own risk or to insure with a casualty insurance company. This individual liability concession has been made, amongst others, to the big steam railway companies as well as to electric railway companies. It is obvious, therefore, that by putting these industries into Schedule II. a material concession has been made that does not apply to the employers grouped in Schedule I. In other words, the employers grouped in Schedule II. are permitted to buy their insurance in the cheapest market. The question arises whether these special concessions should be made only to big corporations, such as the railway companies, etc., while other industries are forced to pay into an accident fund on an assessment basis, thereby making it absolutely impossible for them to know what their insurance will cost. The weakness of this accident fund scheme, or grouping system, has already been demonstrated. The commissioners, according to the official Ontario Gazette dated November 28, have made numerous changes in the groups in Schedule I. and have read a number of industries out of the act altogether. Those that have been read out of the act are liable to common law actions. These changes cannot have been made by reason of any experience on the part of the commissioners in their administration of the act, because the act has not yet come into force.

The government evidently appreciate the weakness of their experiment and fortunately made provision in the new act for the transfer of any industry coming under Schedule I. to Schedule II., so that it is in the power of the commissioners to transfer any one or the whole of those in Schedule I. to Schedule II. In the latter event, the individual liability would apply to every case, just as it now applies only to the big corporations cited above. The present conditions brought about by the war are bound to have a telling effect on the assessment plan scheme, and it is questionable whether it is wise for the government to run the risk of seeing this new legislation fall to pieces.

The appointment of the commissioners is a most commendable feature of the new act. They are a final tribunal in adjudicating upon accident claims in dispute. Litigation should therefore be a thing of the past, as the commissioners' decision will be final. It is not too late for the government to remedy the mistake which seems to have been made. *The Canadian Engineer* does not advise deferring the effective operation of the act, but the commissioners will be conserving the best interests of employers and employees alike if they forthwith transfer to Schedule II. many or all of Schedule I. The workman has nothing to lose by the change. The employer is bound to do one of two things. He must take out insurance covering all the provisions of the new act or put up substantial security with the government to provide for any accidents for which he may be called upon to pay compensation.

THE EXPANSIVE FORCE OF ICE.

In the transactions of the Royal Society of Canada appears a paper by Messrs. H. T. Barnes, J. W. Hayward, and Norman M. McLeod, which contains some very useful information on the expansive force of ice, a matter of very great importance in engineering work in Canada. Allowance for the frost of the ice sheet has been the subject of considerable diversity of opinion, and the conclusions which these gentlemen have reached as a result of their studies, as yet of a preliminary nature, of ice expansion, will be found interesting:

(1) The crushing strength of ice is most probably 400 pounds per square inch.

(2) An ice block will yield under pressure at approximately 200 pounds per square inch, probably due to the slipping of the crystals.

(3) An ice sheet will form cracks on the upper and under surface due to unequal strain.

(4) A permanent expansion may result if the cracks become filled and frozen.

(5) According to the most trustworthy results of other observers, the ice frozen to concrete develops its full crushing strength, and the tensile strength of ice is under 200 pounds per square inch.

INITIAL OPERATION OF CEDARS RAPIDS PLANT.

The extensive power plant which the Cedars Rapids Manufacturing and Power Company has under construction on the St. Lawrence River, about 30 miles west of Montreal, has reached the stage of near-completion. At the present time the company is developing power to a limited extent and utilizing it for lighting the village of Cedars and for power for construction equipment. The work at present is largely of a cleaning-up nature, preparatory to actual commencement of operations next month. It will be remembered that the initial development of 80,000 h.p. has been contracted for, 60,000 of it by the Aluminum Company, for use at Messina Falls, N.Y., and the remaining 20,000 by the Montreal Light, Heat and Power Company. The design calls for an ultimate development of 160,000 h.p.

An incident of particular interest occurred on October 29th, when a berm acting as a cofferdam during the construction of the 2-mile head-race, prematurely gave way, filling the head-race and putting one of the large units into operation. Some small damage was caused as the unit was without oil in its thrust bearing.

The design and construction of this large power plant has been described and illustrated in previous issues of *The Canadian Engineer*. For the bulk of details respecting it, the reader is referred to issues of January 1st, 1914, and July 9th, 1914. The 2-mile earth bank forming the south wall of the canal and extending to the power house was joined to the shore at the head of the canal by an earth bank which acted as a cofferdam and shut off the water from the entire canal and power house site. The bank was of quite sufficient mass, but the company, anxious to make progress, set about to have as much as possible of it removed by steam shovels, so as to enable a speedy completion of the job, when the power house had been completed and ready for operation. The steam shovels had only excavated one cut along its bank when the water broke through, filling the entire canal in a few hours, submerging the shovels and breaking through one of the power house intakes, starting up a 10,800 h.p. unit.

It had been the intention of the contractors to remove the berm after the canal had been filled with water at a gradual rate extending over several days, so as to subject the dike forming the south bank of the head race to as gradual an increase of pressure as possible. The dike resisted the speedy application of hydrostatic pressure thrust upon it, however, and sustained no damage. The accident was undoubtedly a severe test for the dike, the specifications for which called for a concrete core-wall over 8,000 ft. in length.

As for the power unit, the only damage done to it was in the Kingsbury thrust bearing on the top of the generator. It is 5 ft. in diameter and supports a load of over 5½ million pounds. Although in operation for only a short period, before the intake was closed, the heat generated between the bearing surfaces, in the absence of oil, soon burned the babbit out.

According to statistics compiled by the American Iron and Steel Institute in 1913, about seven times as much steel pipe as iron pipe was made in the United States. In 1905 the amount of steel pipe was only a little more than double the amount of iron pipe. The amount of iron pipe produced year by year, however, remains about stationary or slowly declines, while steel pipe production has rapidly increased. The use of steel in making welded pipe was not successful commercially until about the close of the '80's, but has had a very rapid growth in the quarter century since it began, the output in 1913 having been 2,189,000 tons.

SPEEDY CONSTRUCTION AT ROGER'S PASS, B.C.

The following has been announced by Messrs. Foley Bros., Welch & Stewart as the record for November in the construction of the Roger's Pass Tunnel, 26,400 ft. in length through Mount Macdonald of the Selkirk Range:

East end centre heading, 588 ft. schist with some quartzite.

East end pioneer heading, 529 ft. quartzite with some schist.

West end pioneer heading, 817 ft., slate with small quartzite bands.

West end centre heading, 654 ft. slate with small quartzite bands.

The west end pioneer heading footage of 817 ft. in thirty days is believed to be the record for the American continent. It was driven down grade through rock that could not be broken over 6 ft. per round. The greatest footage in a single day was 37 ft.

In our issue of June 12th, 1913, we commented upon the record established by the Mount Royal Tunnel and Terminal Co. in driving 810 ft. in 31 days. In this instance the daily progress averaged 22 to 28 ft. for the greater part of the time.

It is very interesting to note that these two examples of speedy engineering construction are Canadian. While both typify the use to best advantage of the most modern plant and methods of construction, it is all the more interesting in that the tunneling methods differ materially. In the Roger's Pass enterprise the use of a pioneer heading is being tried out for the first time on such a gigantic scale, it being felt that considerable time could be saved by this method. Time was also a vital factor in connection with the choice of methods for the Canadian Northern tunnel, and a bottom centre heading method was adopted with this in mind.

At the present time the pioneer bore of the Roger's Pass tunnel is about two-fifths completed. It is anticipated that the entire work will be finished many months before the specified time. Mr. Joseph Murphy is assistant superintendent east end, and Mr. Joseph Fowler is assistant superintendent at west end.

SOUTH AFRICAN IRON INDUSTRY.

According to a consular report the manufacture of steel from steel and iron scrap has been started at Vereeniging by the Union Steel Corporation of South Africa, Limited. Rolling was commenced at the works of the corporation on August 1, 1913, and a Siemen's steel melting furnace was started on September 1, 1913, upon which date the first ingot of steel produced in South Africa was cast. The full equipment of the works consists of a 10 to 12-ton Siemen's open-hearth melting furnace, a 600-ton press, two Siemen's reheating furnaces and a 12-inch rolling mill. The whole plant is covered in by buildings of galvanized corrugated iron. The scrap yards now contain roughly 20,000 tons of scrap of which about 16,000 tons had been removed by the corporation from the Pretoria depot of the railway administration. The material produced consists of bar iron and steel of all sections, fencing standards, light colliery rails, and so forth.

The number of men employed at the works of the corporation is about 100 Europeans and 90 natives. Most of the skilled operatives have been brought out from England under contract.

THE CRUSHING STRENGTH OF ICE.

VARIOUS values, ranging from 325 to 1,000 pounds per square inch, as determined by a standard United States testing machine, have been presented for the crushing strength of ice. The importance of this, when calculating the expansive force of an ice sheet (referred to editorially on another page of this issue), makes it very desirable for hydraulic engineers to have more accurate knowledge. In 1871 a value of 208 pounds per square inch was given by Czowski for ice below the freezing point. Ludlow estimated it to vary from 100 to 1,000 pounds with an average of 575 pounds, from a study of ice on Delaware Bay. C. A. Mees arrives at a value of 400 pounds per square inch in the following way: He concludes that the crushing strength may attain a value of 800 pounds in a short column, but adds that wherever the effects of ice expansion have been carefully observed, it has been noted that bending takes place and this may be expected because we have, in an ice sheet, a long column effect. On this account, assuming one-half the crushing strength may be developed before bending, the maximum thrust may equal 400 pounds per square inch.

Table I.

Results of Compression Tests (Bell).

No. of test.	Size of cube.	Crushing strength.	Lbs. per sq. inch.	Temp.'s Ice.	Temp.'s Air.	Remarks.
1	2 x 2	1,926 lbs.	481.5	18	27	1 23/32 height after crushing.
2	2 x 2	2,059 "	516	18	27	1 23/32 " "
3	1¾ x 1¾	3,430 "	1,128	13	25	
4	1 15/16 x 2	2,074 "	535	32	40	Grain perpendicular to line of force.
5	1¾ x 2	2,224 "	636	32	38	Grain parallel to line of force.
6	1¾ x 2	1,884 "	538	32	39	" " " "
7	2⅛ x 2⅛	3,400 "	753	32	40	" " " "
8	2¼ x 2¼	2,474 "	488	32	40	These were 4 inches long and had grain parallel to line of force.
9	2¼ x 2¼	1,811 "	358	32	40	
10	1⅞ x 2⅞	3,214 "	783	32	40	Perpendicular to line of force.
11	2⅛ x 2⅛	3,449 "	765	32	40	Parallel to line of force.

Results of Adhesion Tests (Bell).*

No. of test.	Size ice.	—Bevel— Hor.	Vert.	Load at failure.	Unit compression at failure.	Unit adhesion to concrete.	Method of fail.	Temp. Fahr.
1	2⅞ x 3⅛	12	8	4,200	370 lbs.	195	crushing	30°
2	2¾ x 2¾	12	8	3,800	504 "	228	"	30°
3	3⅛ x 3½	8	12	3,856	395 "	158	crushed and sheared	32°
4	3⅜ x 3½	8	12	2,960	250 "	116	adhesion	32°
5	3⅛ x 3⅛	1	1	4,100	420 "	185⁵	compression	30°

*Adhesion of ice to concrete blocks.

Table II.

Date.	No.	Size of block.	Direction of axis with respect to direction of applied pressure.	Pressure when first crack was heard.	Pressure when block crushed.
Mar. 21	3	3½ x 6½ x 4¾	Parallel	87 lbs.	289 lbs.
"	4	6½ x 5 x 4¼	Perpendicular	123 "	247 "
"	5	4½ x 4¼ x 5¾	"	183 "	251 "
"	6	5¼ x 4 x 6	Parallel	166 "	335 "
Mar. 26	7	7¼ x 6 x 6	Perpendicular	183 "	424 "
" 26	8	7¼ x 6 x 6	"	183 "	364 "
" 26	9	6½ x 6 x 6	Parallel	....	485 "
" 26	10	7½ x 7 x 5¼	Perpendicular	....	238 "
" 26	11	7 x 7 x 6¼	"	200 "	400 "
" 26	12	7½ x 6 x 6	Parallel	121 "	304 "
" 26	13	7½ x 6 x 5½	"	159 "	398 "
" 26	14	7½ x 6¼ x 5¾	Perpendicular	140 "	292 "
" 26	15	7¾ x 6½ x 5¾	"	234 "	422 "
" 26	16	7 x 7 x 5½	"	227 "	568 "
" 26	17	7 x 6½ x 6	Parallel	....	224 "
" 26	18	6⅛ x 6 x 5⅞	"	248 "	557 "

Mean 370 lbs. per sq. inch, axis parallel.
" 356 " " axis perpendicular.

Mean of both 363 lbs. per sq. inch.

Table I. gives the results of a valuable series of experiments by George G. Bell, who used small cubes of approximately 2 inches.

This information is introductory to a paper on the subject presented last May to the Royal Society of Canada by Professor H. T. Barnes, of McGill University,

Montreal. Dr. Barnes is inclined to neglect Mr. Bell's highest result, thereby securing more consistent values, ranging from 358 to 783 pounds per square inch. Mr. Bell himself states that he considers 400 pounds a fair estimate of the crushing strength of ice from all his tests.

Dr. Barnes describes experiments performed by himself to determine the crushing strength of perfectly clear ice on somewhat larger blocks. The ice was cut from the river and tested in a hydraulic press. One large piece 6 in. x 28 in. x 40 in., furnished the largest number of individual blocks. The direction of the crystalline axis was determined by knowing the plane of freezing, and the various blocks were cut by a hand-saw accordingly. The ends of the blocks were melted smooth on a hot plate to fit the plates of the press. When the pressure was applied, considerable melting resulted on the ends. The blocks were kept outside at a temperature ranging from —8° C. to 0° C. and were brought into the laboratory for the tests. One interesting fact was noted, that the blocks were heard to crack at a pressure, approximately one-half the ultimate crushing force. It was repeatedly observed that as soon as the pressure was increased sufficiently to cause the first audible crack, the block appeared to stiffen, and the pressure ran up much quicker, with much less melting. In some cases the melting appeared to cease altogether. Dr. Barnes concluded that the giving way of the ice under pressure allowed the melted ice to run into cracks, where it must have frozen and cemented the block more firmly, being unable to see any of the cracks which could be distinctly heard at half the crushing pressure.

The only effect of varying the position of the axis of the ice with respect to the direction of the pressure, appeared to be the way the block burst. When the axis was parallel to the applied pressure, the ice burst sideways into innumerable long needles, resembling a cake of ice which has all but fallen to pieces in the sun. The cake fell to pieces on being removed from the press. When the axis was at right angles to the applied force, the block cracked lengthwise and transversely without shattering.

Table II. gives the results of the tests performed by Dr. Barnes. It will be seen that the mean value for all the tests for parallel axis is a little higher than the mean for perpendicular axis, but the difference is too small to make it possible to draw any definite conclusions. The results show considerable variation, which may be purely accidental or may have some bearing on the character of the initial distribution of the pressure.

The relation between the first cracking of the ice and the final crushing force is one which, the experimenter states, must be further investigated.

In closing he remarks: "The question of the relation of temperature to the crushing strength is one of importance. It has been assumed that ice becomes stronger at low temperature. The hardness of ice increases considerably as the temperature falls to 0° F. but I am inclined to think that the ice also becomes more brittle. In the neighborhood of the freezing point, ice is much more plastic than it is at lower temperatures. The plastic effect is, however, masked by the regulation effect, and it is a question whether the ice mass is not really firmer near the freezing point than when cooled much below. This can, however, only be settled by further experiment."

A number of samples of radium-bearing ore from British Columbia have been received by the mines branch, Department of Mines, Ottawa, for investigation.

THE SUCCESSFUL BURNING OF LIGNITE.

In *The Canadian Engineer* for December 3rd, 1914, the investigations of the Saskatchewan government into the coal resources of the province were referred to, and an analysis was given to illustrate its serviceability as fuel for power and domestic purposes.

Following it we present herewith some notes respecting the burning of lignite in the State of Texas, in which state there is an estimated area of over 60,000 square miles, containing what is roughly concluded to be 30 billion tons of lignite. In many centres its use in manufacturing plants has been extensively adopted. The lignite resources of the state have been recently investigated by Professor Wm. B. Philips, of the University of Texas, who has made a study of its commercial use. In a recent report he alludes to the introduction of a grate specially adapted to burn lignite screenings, a grade that is sold at from 50 to 60 cents per ton. This grate is similar to the ordinary grate, being rectangular in cross-section, but slightly wider at the top than at the base. On its top face are marginal and transverse ribs or partitions, forming fuel pockets adapted to retain fine fuel. On its bottom face are recesses forming air pockets. These fuel pockets are from one-half to five-eighths of an inch deep and are connected with the air pockets by tapered ventilating holes, largest at their lower ends, being about three-eighths of an inch in diameter at the top and 50% larger at the bottom. The tapering form of the ventilating holes tends to cause a discharge of the air in jets into the fuel.

In ordinary grates, especially where a forced or induced draft is used, the air rushes through the weakest places in the fire. With this grate the individual air pockets underneath prevent the air from rushing past some of the ventilating holes and overcharging others. These air pockets form sources of supply to the separate groups of ventilating holes and cause an even distribution of the air to the fuel pockets in the top of the bar throughout the grate surface. A steam blower is used with these grates.

Much lignite is now fired by hand, and while this method unquestionably gives good results when proper care is taken, the stoker seems to be necessary for large establishments. There are no difficult obstacles to be overcome. The main points to consider are that lignite is a fuel which parts with its volatile combustible matter more quickly than does ordinary bituminous coal and that the fixed carbon is not of a coking nature. This means that a large quantity of air must be supplied within a short time after the fuel begins to part with its volatile combustible matter and is supplied at the requisite points. The smoke must be prevented from forming, for it is difficult to handle it afterwards. The fixed carbon will take care of itself, if prevented from falling through the interstices of the grate; it is the volatile combustible matter that has to be cared for.

It does not appear that there are greater variations in the composition of lignites than in the coals with which they are to compete, so that a stoker installation successful with one lignite should be capable of burning any other under comparable conditions.

It has been stated in Ottawa that the value of minerals produced in Canada this year will be considerably less than that of 1913, because of the scarcity of capital for mining development and also because of the low prices which have existed for silver and other minerals.

TIDEWATER ACTIVITIES AT HALIFAX.

CONSIDERING the effect which the war and the anteceding depression has had upon engineering work in general, the progress that has been made during the past several months on the Intercolonial Railway ocean terminals under construction at Halifax, is inspiring and more or less remarkable. The work on the superstructure of pier No. 2 has made material advancement, as has also the railway cuttings and other phases of the whole scheme. The general details of the terminal plans were given in *The Canadian Engineer* for July 30th, 1914. Briefly, the terminals will extend for 1 ¼ miles southward from Fawson Street along the western shore of Halifax Harbor. They provide for a bulkhead passenger landing quay 2,000 ft. long, and four new piers from 650 to 800 ft. long and 235 ft. broad, the whole protected at the southern end by a rubber mound breakwater a quarter of a mile long. Ample railway tracks and connections, sheds and equipment, grain elevator, etc., will be provided for the handling of passengers and cargo, and a special feature of the terminals will be the exceptionally good facilities for the handling of passengers, mails and express freight. Extensive immigration quarters will be provided at the passenger landing quay. The quays will provide for depths ranging up to 45 ft., and will therefore be ample for the largest transatlantic liners afloat.

View, Looking South, of No. 2 Shed, While Under Construction.

Entrance to Reinforced Concrete Freight Shed, Pier No. 2.

A part of the scheme is the Halifax Ocean Terminals Railway, a double track line from Rockingham, four miles from North Street station, Halifax, to the site of the new terminals. Thus the existing line of the Intercolonial will be connected with the quay. The line includes the formation of a freight terminal yard and a diversion of the I.C.R. at Bedford Basin and at Fairview. It passes under the Halifax and South Western Railway and follows the North West Arm to Young Avenue. This portion of the line includes a cutting, mostly through rock, and of sufficient depth to pass under all existing roads and streets with very slight alterations. Grade crossings have been entirely eliminated and the location of the railway along the North West Arm and the south end of the peninsula was decided upon with a special view toward the preservation of the natural beauty of these suburban and residential parts of the city. Railway construction work has included a large amount of filling along the west shore of Halifax harbor for the proposed bulkhead, quays and piers.

The contract for the grading of the railway was awarded a year ago last June to the Cook Construction Company and Wheaton Bros., and work commenced early last fall. Grading included earth cuts 22 ft. wide for single track with an additional 13 ft. for each extra track. In rock the widths were 20 ft. and 13 ft. respectively with slopes of ¼ to 1. Embankments were to have a grade width of 16 ft. or 18 ft. when under or over 16 ft. in height, respectively. The earth slopes were to be 1½ to 1. The maximum grade is 6/10%, compensated for curvature and the sharpest curve, 4%. This contract included the construction of the freight terminal yard and breakwater. Materials for both were provided by the excavations from the railway cuttings. The breakwater embankment consists of rock protected on the sides and seaward extremity by rubble rip-rap and paved on the top with large angular pieces of rock.

Specifications call for a core embankment 40 ft. in width at low-water level of ordinary spring tides. Side slopes 1 : 1 extend from the bottom of the harbor to low-water level. From its base to 30 ft. below water level the embankment consists of varying sized rocks. In the upper portion these rocks are not to weigh less than 1 ton each. The sides have large angular blocks for protection to 30 ft. below water level, these blocks weighing from ½ ton to 2 tons each. On the seaward slope the rip-rap is to be composed of blocks weighing from 2 to 8 tons. This is also the required weight of blocks from the top of the embankment at low-water level to the top of the breakwater. The breakwater will measure 30 ft. in width across the top, and is to be evenly surfaced with all interstices tightly packed.

The buildings for the new terminal include a passenger station, the plans for which have recently been prepared by Ross & Macdonald, Montreal. Plans for other buildings to be constructed upon the piers are now being prepared. The contemplated arrangement includes a power house to furnish light, heat and power, a grain elevator and the large freight shed with abundant trackage facilities for the rapid handling of freight.

The pier, which is the widest in Canada, and which has a floor area of 258,000 sq. ft., is one which, owing to its piling problems, difficulties of concrete construction, length from bulkhead, spacious yard room, etc., has occasioned much admiration from the maritime provinces. At the present time concreting has been practically completed on the freight shed structure, and the building glazed. Accommodation is being provided in it for 2,000 passengers. This accommodation is but temporary and will be removed when the new passenger station has been built.

Four tracks along the south, two in the centre of the building and one on the north side of it, are being installed, the latter three running the full length of the shed. The present immigration building will be removed to permit the laying of the north tracks which will also require, for support, an extension of the bulkhead. This work will be held over until spring.

TELESCOPE FOR VICTORIA OBSERVATORY.

THE Dominion Government contemplates the erection next year of new observatory buildings on Saanich Hill, in the vicinity of Victoria, B.C. The telescope to be installed there during the year was the chief subject in an illustrated address delivered by Dr. J. S. Plaskett, of the Dominion Observatory, Ottawa, at a meeting on December 1st, of the Royal Astronomical Society of Canada, Toronto. The construction of the telescope has been under way for some time. The disc for the main mirror is being ground at the works of the John A. Brashear Co., Pittsburgh. It is 73⅝ inches in diameter and 13⅛ inches thick, and weighs 4,960 pounds. The aperture in the centre of the disc is 9 inches in diameter. The disc itself was made at the Belgian factory of the St. Gobain Glass Works, and shipped from there three days before the outbreak of the war. Dr. Plaskett describes the construction of the mirror as follows:

The mirror-disc is ground and polished on the back surface only approximately, not optically, flat. The front surface, however, the one facing the sky, is carefully and most accurately ground, polished and figured to the correct curve, which is a parabola of revolution. Then this surface is carefully silvered with a thin bright coat of silver, highly polished, reflecting back the light, which hence does not enter the glass at all. As long as the front surface of the glass is perfect, and the rest of the material is sufficiently homogeneous and rigid to hold this surface perfect and unchanged, it does not matter about its transparency or freedom from bubbles or minor defects.

After reflection at the concave surface of the big disc the light from the star proceeds back up the tube in a converging cone towards the focus of the upper mirror. It may be observed in three ways: (1) It may be received on a bent telescope, one with a right-angled prism in it, and the enlarged images may be viewed at the side of the tube. This is the prime focus arrangement. (2) A plane mirror at an angle of 5 degrees may intercept the cone of light about three and a half feet below the focus, thus forming the images at the side of the tube, where they may be viewed by the eyepiece. This is the Newtonian arrangement. (3) The light may be intercepted about seven feet below the focus by a convex mirror, which reflects the light back through the hole in the centre of the big mirror-disc, forming the images anywhere desired along the optical axis generally, of course, a foot or so below the big disc. Here they can be viewed by eye-pieces. This is the Cassegrain method.

The Cassegrain and Newtonian attachments intercept between six and seven per cent. of the light incident upon the big mirror, but when the images are viewed at the focus the quality is not affected at all; the quantity of light only is slightly diminished. Exactly the same effect would be produced by sticking a circular disc of paper one inch in diameter centrally over a four-inch objective. The image would not seem to be affected.

The construction of the telescope mountings has been under way for some time. The heavy steel castings are being made for the Warner & Swasey Company in Pittsburg and Cleveland and are to be delivered in about four months' time. All the mechanism and smaller parts are being made at the Warner and Swasey works, and it is expected that the entire mounting will be ready for shipment next October.

The plans for the dome and the building for the telescope are practically completed. The walls are to be about 35 ft. high, and the dome about 35 ft., making the total height over 70 ft.

The plan for the office building provide for a large library, which will also be used as a lecture room, with seating for 200 people.

The plans for the other buildings required are well under way. The contracts for the buildings first needed will be let as soon as possible in the New Year, so that construction may begin on April 1. There is every prospect, therefore, that the telescope will be installed during 1915.

AMERICAN ROAD BUILDERS' ASSOCIATION.

The eleventh annual convention of the American Road Builders' Association, to be held in Chicago, December 14th to 18th, inclusive, has attracted the attention of many Canadian highway engineers, and a more than usually representative attendance from this country will likely be in evidence. Among those who have signified their intention of being present are Hon. F. G. MacDiarmid, Minister of Public Works for Ontario; Hon. E. H. Armstrong, Minister of Public Works for Nova Scotia; Mr. John Stock, Deputy Minister of Public Works for Alberta; W. A. McLean, Provinical Highway Engineer for Ontario; W. G. Yorston, Provincial Highway Engineer for Nova Scotia; S. T. Robinson, chairman of the Highway Board of Saskâtchewan; A. McGillivray, engineer to the Manitoba Highway Commission. Representatives of various Canadian cities, of the Toronto Harbor Commission, and similar bodies throughout the Dominion, will also be in attendance.

SOME INTERESTING MOTOR-TESTING EQUIPMENT.

There is an interesting installation in New York where investigations of various kinds on steam engines, particularly of the turbine and rotary type, are carried out. The equipment includes high-speed indicators of the "manograph" type by means of which diagrams can be obtained at speeds as high as 2,000 revolutions per minute, as well as at ordinary low, piston speeds. Another notable feature is the apparatus for making brake tests. This includes an 80 h.p. electric dynamometer with rocking fields, built by the Sprague Electric Works, and also a Heenan and Froude hydraulic dynamometer of the model used by the British Admiralty, having a maximum capacity of 600 h.p. at 5,000 revolutions per minute. Steam is available at 480 pounds per square inch. These facilities have recently been installed in the laboratories of Mr. Joseph Tracy, 1790 Broadway, New York.

The suggestion has been made, and it has been stated that the Government will likely act upon it, that aliens of enemy nationality, who have been placed in charge of the military authorities, be set to work cutting roads and clearing tracts for settlement in the clay belts of Ontario and Quebec.

Coast to Coast

Haileybury, Ont.—Messrs. P. H. Secord and Sons, contractors, have just turned over the newly-completed drill hall to the Department of Militia.

Porcupine, Ont.—The output of the Dome Lake mines has been increased by some 15 tons daily by the addition of extra tables and equipment, put into operation last week. This brings the capacity of the mill up to 50 tons per day.

Cranbrook, B.C.—The branch of the Kootenay Central from Cranbrook to Golden was formally open last week, connecting the Crow's Nest with the main lines of the C.P.R. and traversing one of the most fertile parts of the province.

Princeton, B.C.—Southern British Columbia is looking forward with great interest to the linking up of the boundary valleys with adequate railway facilities, and the good progress that is being made on the Kettle Valley Railway is an assurance that the advent of better transportation will not be long delayed.

Galt, Ont.—The Lake Erie and Northern Railway is ready for business. Work has been rushed along during recent months, ballasting has been proceeded with briskly, and the bridge across Mill Creek, paralleling that of the Grand Trunk Railway, was completed last week.

Portage la Prairie, Man.—The electric railway line into Stonewall is practically completed, there only remaining a little overhead work to be done. Regular service between Winnipeg and Stonewall will likely be in operation before the middle of the month.

Vancouver, B.C.—The greater part of $10,000 a month will be spent, to provide employment during the winter, in the grading of boulevards and streets. Mr. F. L. Fellowes, the supervising city engineer, has closely inspected the entire city, and has made a number of recommendations for extensive improvements in this respect.

Hamilton, Ont.—Engineers of the Department of Public Works, Ottawa, were in Hamilton last week inspecting a revetment wall on the Bay front, which for a distance of about 40 ft., has bulged 31 inches out of alignment as the result of pressure from back-fill. It is estimated that the expenditure connected with the straightening of the wall will be about $25,000.

Toronto, Ont.—Some difficult excavation work has been encountered by the sewers department in connection with the driving of the large trunk sewer tunnel under the C.P.R. tracks near Woodville Ave. At this point the sewer is about 40 feet below the tracks. Compressed air has been used on the job for preventing the intrusion of water, the seepage of which is overabundant.

Winnipeg, Man.—The W.S. and L.W. Ry. have completed the construction of their electric car line from Winnipeg to Stonewall and a service will be in operation about December 15th. Besides 17 miles of 13,200 volt line and track, this work included a subway beneath the C.P.R. Beach line at Middle Church, a sub-station and station house at Stony Mountain, and a station house at Stonewall.

Edmonton, Alta.—As announced in another column of this issue, a contract has been let to D. F. McArthur and Co., for the construction of a line 186 miles in length from Lac la Biche to Fort McMurray. The announcement was made last week by Mr. J. D. McArthur, president of the E.D. and B.C. Railway. It is expected that the new line will be finished by November of next year. It will involve an expenditure of about $2,000,000.

PERSONAL.

A. C. McKENZIE has been appointed town engineer of Preston, Ont.

H. M. PASSMORE has been appointed secretary to the Minister of Public Works of Ontario.

J. W. PUGSLEY has been appointed secretary of the Department of Railways and Canals, Ottawa.

LAWFORD GRANT, sales manager of the Eugene Phillips Co., Montreal, is at present in England on a business trip.

LIEUT. A. L. MIEVILLE is in command of the Toronto section of Canadian engineers now in training at Ottawa.

GEORGE A. JANIN, chief city engineer of Montreal, is to receive a commission enabling him to proceed with the company organized by himself, with the second contingent.

E. W. BEATTY has been appointed vice-president and general counsel of the Canadian Pacific Railway Co. Mr. Beatty has been associated with the legal department of the company since 1901.

H. O. FISKE, until recently connected with the Peterborough (Ontario) Light and Power Co., succeeds Mr. C. B. Howse as manager of the Utilities Commission of that city.

C. BRENNAN, one of the construction engineers of the Edmonton, Dunvegan and British Columbia Railway, is superintending the cutting of the right-of-way of a 60-mile section of the line beyond Smoky River.

Dr. C. J. HASTINGS, Medical Officer of Health for Toronto, was elected first vice-president of the American Public Health Association at the closing session of its annual convention in Jacksonville, Fla., last week.

GEO. W. CRAIG, city engineer of Calgary, had the misfortune to meet with a painful accident while in Omaha, Neb., last week. We are informed that Mr. Craig is improving and will return to Calgary in a few days.

W. A. McLEAN, Provincial Highway Engineer of Ontario, is president of the American Road Builders' Association, and will spend next week in Chicago, where he will preside over the sessions of the eleventh annual convention.

C. L. HERVEY, C.E., chief engineer of the new Glengarry and Stormont Railway, which connects Cornwall with the C.P.R. at St. Polycarpe, Que., was tendered a complimentary luncheon upon the occasion of the completion of the laying of steel last week.

FRED. D. NIMS, electrical engineer and general superintendent of the Western Canada Power Co., Limited, is leaving the service of that company to accept a position with the Olympic Power Co., of Port Angeles, Wash. Mr. Nims deserves special mention for his successful efforts to form a section in Vancouver of the American Institute of Electrical Engineers. Mr. Nims is a member of several of the standing committees of the Institute.

OBITUARY.

The death occurred at Ashtville, North Carolina, of J. T. M. Burnside, B.A.Sc., in his 40th year. Mr. Burnside was a graduate in engineering of the University of Toronto, graduating in 1899, and engaging in mining for several years. He then turned to military affairs, and held a commission in the 48th Highlanders Regiment. Later he transferred to the British army and for some time was stationed on the Gold Coast. A few years ago Mr. Burnside engaged in rail-

way building in China, afterwards returning to Canada and devoting his attention to mining in the Cobalt region. Impaired health induced him to go South, where death overtook him.

Death came suddenly last week to Mr. Frank Rankin, of Haileybury, a member of the engineering staff of the Transcontinental Railway.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

The meeting of the Mechanical Section of the Canadian Society of Civil Engineers, held in Montreal on the evening of December 3rd, was addressed by Mr. C. Brady, his subject being "Steel Passenger Car Frame Construction." Mr. Brady's paper was a neat and masterly treatment of the subject, and was well received by the members. An abstract of it appears on another page of this issue.

Following it an address was given by Lieut. Shirley T. Layton, A.M.Can.Soc.C.E., a graduate of R.M.C. and of McGill University. The speaker dwelt upon the primary object of artillery in modern warfare, explaining it to be for the protection of the advancement of infantry and assistance to its movements. The secondary object was the destruction of the enemy's war equipment. Such interesting points as the uses of different classes of artillery, including horse artillery armed with 13-pound guns, field artillery with 18-pounders, and others of larger order, made Lieut- Layton's paper a most instructive one for the members. He observed that in Montreal there were two heavy artillery batteries, armed with 60-pound guns, one having gone with the first contingent. The remaining battery was now armed with 4.7-inch guns, throwing shells weighing 45 pounds. This gun was well described by the speaker. Its mechanism and ammunition were illustrated by slides. The gun weighs about 4½ tons and the maximum range given on the sight drum is 9,600 yards. It has great power and is remarkably accurate at long ranges. The speaker emphasized its usefulness in bringing cross-fire to bear upon the enemy and also against buildings and fortifications. The recoil of the gun, method of loading and timing of shell explosion were explained in detail. The construction of different kinds of shells and the devices to prevent premature explosion were described.

It may be said of Lieut. Layton that some time ago he left the engineering staff of Walter J. Francis and Co., to accept a commission, and since that time he has recruited the whole number for the Montreal part of the Heavy Brigade, which will go with the next contingent. It is interesting to note in this connection that the Heavy Brigade in Montreal has been in charge of Lieut.-Col. Lacey R. Johnson, also a member of the Society. About 120 members of the Society are participating in active service.

NOMINATIONS, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The following is a list of members who have been nominated for the various offices of the Canadian Society of Civil Engineers for the year 1915:—

For President, F. C. Gamble, Chief Engineer, Public Works Department, Victoria, B.C.; for Vice-President for 3 years, A. E. Doucet, District Engineer, National Transcontinental Ry., Quebec; A. St. Laurent, Public Works Department, Ottawa. For Vice-President for 1 year, E. E. Brydone-Jack, Professor of Civil Engineering, Manitoba University; Gordon Grant, Chief Engineer, National Transcontinental Ry., Ottawa.

For councillors, District 1, S. P. Brown, Chief Engineer, Montreal Tunnel, etc., Canadian Northern Ry.; H. R. Safford, Chief Engineer, G.T.R.; A. Surveyer, Montreal; R. M. Wilson, Montreal. District 2, C. B. Brown, Chief Engineer, Canadian Government Railways, Moncton, N.B.; F. W. W. Doane, City Engineer, Halifax, N.S. District 3, A. Amos, Quebec; T. A. J. Forrester, Quebec. District 4, G. J. Desbarats, Deputy Minister Naval Service, Ottawa; A. J. Grant, Superintending Engineer, Trent Canal, Peterborough, Peterborough, Ont. District 5, S. B. Clement, Chief Engineer, T. and N.O. Ry., North Bay, Ont.; J. L. Weller, Engineer in Charge, Welland Ship Canal, St. Catharines, Ont. District 6, W. G. Chace, Winnipeg; F. H. Peters, Calgary, Alta. District 7, N. J. Ker, Vancouver; D. O. Lewis, District Engineer, Canadian Northern Pacific Ry., Victoria, B.C.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.

The following speakers are among those who have arranged to prepare papers for presentation at the coming convention of the Association in Toronto, January 26th, 27th and 28th, 1915:—A. C. McKay, Principal of Toronto Technical Schools, "Toronto Technical Schools and their Relation to the Manufacture of Clay Products"; W. W. Smith, Shallow Lake, Ont., "The Making and Burning of Drain Tile"; A. F. Greaves-Walker, Manager, Sun Brick Co., Toronto, " Kiln Kinks"; E. W. Knapp, "Possibility of Manufacturing High-Class Paving Bricks in Ontario"; Andrew Kruson, "Cheap Glazes for Use on Ontario Clays and Shales"; and Philip W. Green, B.A.S.C., A.M.Can.S.C.E., "Standardization of Clay Products from an Architect's Point of View."

TORONTO BRANCH CANADIAN SOCIETY OF CIVIL ENGINEERS.

A meeting of the Toronto Branch of the Canadian Society of Civil Engineers is being held this evening (December 10th), and is being addressed by J. E. Noulan Cauchon. The subject of his address will be the town planning problem, with special reference to the railway features.

COMING MEETINGS.

AMERICAN ROAD BUILDERS ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.—Annual Convention to be held at the King Edward Hotel in Toronto, January 26, 27, and 28, 1915. Secretary, G. C. Keith, 32 Colborne Street, Toronto.

EIGHTH CHICAGO CEMENT SHOW.—To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.

AMERICAN WATERWORKS ASSOCIATION. — The 35th annual convention, to be held in Cincinnati, Ohio, May 10th to 14th, 1915. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—Annual meeting to be held at the Iowa State College, Ames, Iowa, June 22nd to 25th, 1915. Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

ROSEDALE SECTION, BLOOR STREET VIADUCT

PORTION No. 2 OF THE PROPOSED $2,500,000 STRUCTURE TO BRIDGE THE DON AND ROSEDALE VALLEYS IN NORTHEAST TORONTO.

IN *The Canadian Engineer* for October 29th, 1914, a description was given of the larger section of the proposed viaduct to connect Danforth Avenue (east of the Don River) with Bloor Street, thereby linking it and the surrounding district with the older business thoroughfares of the city. While the article dealt chiefly with the design, executed by the Department of Works, for a 1,618-ft. section of the proposed development, it included an interesting summary of preliminary investigations of site and foundation tests. That portion, known as the Don section, was opened to tendering of both steel and concrete interests last July, and the tenders that have been under consideration have included five for steel and five for concrete. The concrete tenders were all based upon designs submitted by the contractors themselves, while the steel tenders were based upon the design of the Department of Works, described in the article referred to above. On Friday, December 11th, the city council awarded the contract for this section to Messrs. Quinlan & Robertson, Montreal, the price being $996,564.81, it being the lowest steel tender, although it was about $147,500 higher than the low tender for a concrete viaduct.

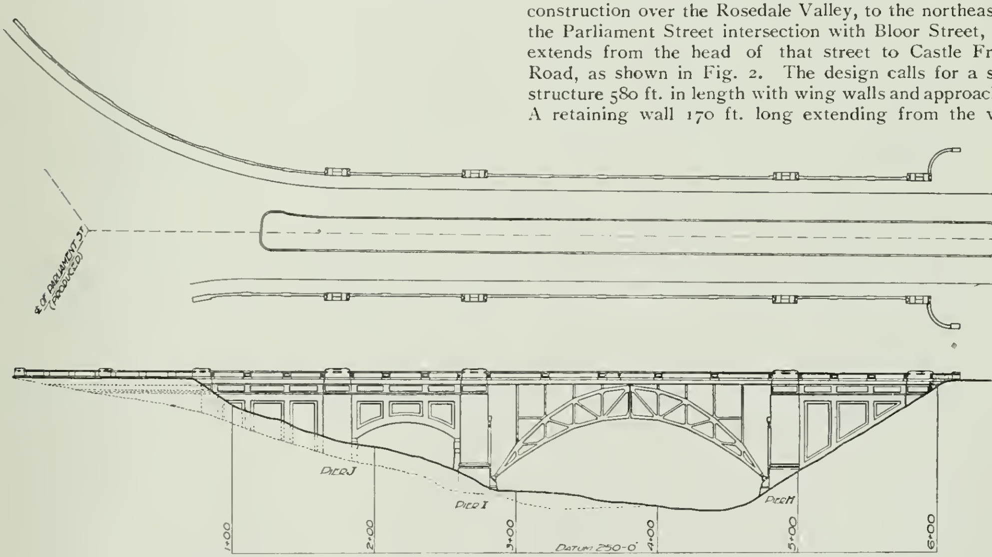


Fig. 1.—Plan and Elevation of the Proposed Rosedale Section of the Bloor Street Viaduct, Toronto.

The Rosedale section of the project provides for the construction over the Rosedale Valley, to the northeast of the Parliament Street intersection with Bloor Street, and extends from the head of that street to Castle Frank Road, as shown in Fig. 2. The design calls for a steel structure 580 ft. in length with wing walls and approaches. A retaining wall 170 ft. long extending from the west abutment of the bridge toward Sherbourne Street, and on the north side, forms an interesting part of the design. The bridge itself includes a 190-ft., 3-hinged steel arch span with steel spandrels and with a 64-ft. rise. This arch is of the same type as the arches on the Don section, previously described. Similarly, there will be an 80-ft. span corresponding in design to that of the Don structure. The cross-section of the bridge is similar to that of the other section, having a total width of 86 ft. from the outer edge of the railing. The centre 22 ft. will be devoted to two street railway tracks. On either side the

design provides for a 20-ft. roadway, bordered on the outside by cantilevered sidewalks $10\frac{3}{4}$ ft. wide. The height of the roadway above the Rosedale Valley drive will be 94 ft. In many respects the general design of the Rosedale section corresponds to the design for the Don section. The specifications also are practically the same for the former as those for the latter. The loading diagrams as well as the clearance diagram for the lower deck, are the same in both cases, and are as illustrated in Figs. 3 and 4, respectively. In Fig. 3, A gives the loading on the upper deck for a 50-ton electric car; the loading diagram, C, is for a 20-ton motor truck, while B denotes the loading for a train of cars on the lower deck. It is to be noted that provision is made here for the future development of a lower deck, as in the case of the other section.

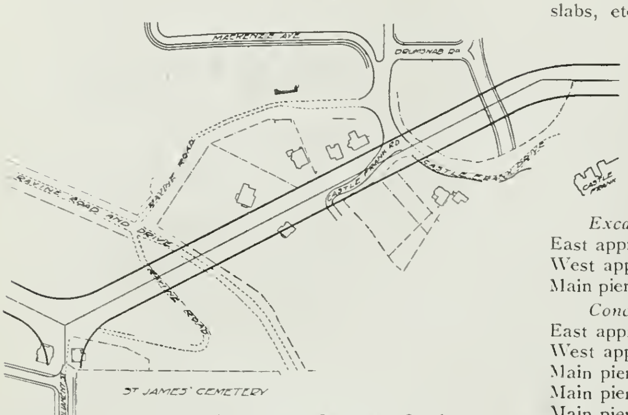


Fig. 2.—Location of Rosedale Section.

The retaining wall is of interesting design, calling for a wall of counterfort type for 69 ft., with a maximum height of 24 ft., the buttresses being spaced 15 ft. c. to c. The remaining portion of the wall will be of cantilever type.

The work and materials required in the construction of the Rosedale section involve about 31,100 cubic yards of excavation for the east and west approaches and for the piers. There will be about 16,900 cubic yards of concrete work in piers, approaches, retaining wall, floor slabs, etc. Reinforcing steel to the extent of about 486,000 pounds will be required, and the structural steel will have a weight of about 3,063,000 pounds. Provision for the lower deck of the Rosedale section (identical in cross-section to that proposed for the Don section) will require about 352,000 pounds of structural steel and 320 cubic yards of concrete. The engineer's estimate of quantities, in brief detail, is as follows:—

Excavation:	
East approach, cu. yds.	21,207
West approach, cu. yds.	1,819
Main piers, cu. yds.	8,082
Concrete:	
East approach, cu. yds.	[1]2,252
West approach, cu. yds.	[2]2,267
Main pier H, foundations, cu. yds.	1,847
Main pier H, body, cu. yds.	3,038
Main pier I, footing, cu. yds.	829
Main pier I, body, cu. yds.	2,610
Main pier I, top, cu. yds.	305
Main pier J, footing, cu. yds.	610
Main pier J, body, cu. yds.	1,540
Main pier J, body, cu. yds.	1,540
In floor, cu. yds.	[3]1,450
Concrete parapet and railing, lin. ft.	1,080
Reinforcing Steel:	
East approach, lbs.	38,100
West approach, lbs.	35,060
Retaining walls, lbs.	19,430
Floor, lbs.	193,260
Pier H, lbs.	46,090
Pier I, lbs.	64,890
Pier J, lbs.	39,970
80-ft. span, lbs.	16,310
Steel Work:	
West approach, lbs.	306,600
80-ft. span, lbs.	451,770
190-ft. span, lbs.	1,501,040
Upper parts piers H and I, lbs.	143,300
Metal in expansion joints, lbs.	7,300
Cast iron pedestals, lbs.	7,600
Cast iron gullies and catch-basins, lbs.	32,300

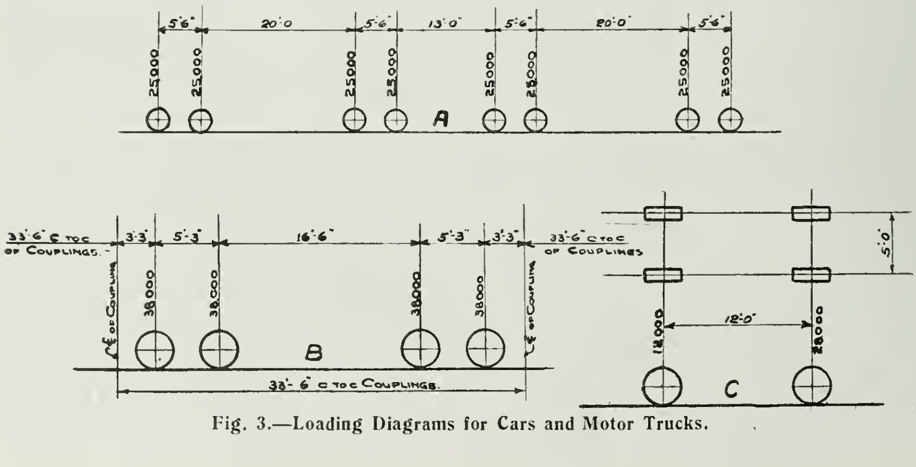


Fig. 3.—Loading Diagrams for Cars and Motor Trucks.

Waterproofing:

Track allowance, membrane and mastic, sq. yds.	1,306
Roadway, felt and waterproofing compound, sq. yds.	2,578
Back of retaining wall, sq. yds.	460
Granite bearings for 190-ft. span, cu. ft.	455

[1]Of this total 228 cu. yds. is in footings for east abutment, 970 cu. yds. is in body of abutment and wing walls, 221 cu. yds. is in north longitudinal walls and 324 cu. yds. in a cross-wall above footings. [2]This includes 620 cu. yds. in body of west abutment, 320 cu. yds. in longitudinal walls, 190 cu. yds. in soffit of 80-ft. span and 284 cu. yds. in side walls of 80-ft. span. [3]Of this 1,257 cu. yds. is floor slab.

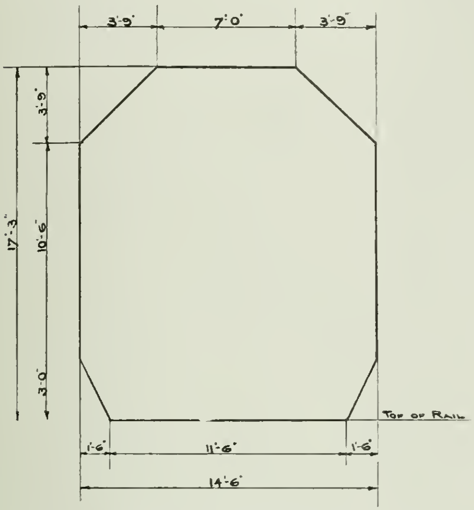


Fig. 4.—Clearance Diagram for Lower Deck (contemplated for the future).

The material required for the lower deck includes the following:—

Steel in stringers, floor-beam stiffeners and anchor bolts, lbs.	352,000
Concrete in slabs, cu. yds.	316
Steel reinforcement in slabs, lbs.	32,300
Hook bolts in slabs, lbs.	550
Cast iron gullies and shoes, lbs.	11,800
Waterproofing, membrane and mastic, sq. yds.	510

Tenders for the Rosedale section were advertised for early in November and will be received up to December 21st, 1914. As in the case of the Don section, bids for steel will be accepted on the plan of the Department of Works, as described herein, and also on a reinforced concrete structure, in which case the tenderer will submit his own plans and specifications.

Among the latest incorporations is that of the Walkerville Roofing Mfg. Co., Limited, capitalized at $60,000. Messrs. J. T. Sullivan, L. H. and C. J. Cheesement are associated with the new concern.

FLOW OF STEAM THROUGH PIPES.

There is perhaps no phase of power-plant design in which the rule-of-thumb methods are still adhered to so commonly as in the determination of the proper size of steam pipes.

Several reasons are attributed by "Power" to this: The commonly accepted formulas are complex, are not any too well substantiated by experimental data nor based on sound theory; the tables given by various writers are incomplete and inconvenient. The engineer who installs pipes which are too large will seldom be criticized, for the mistake shows but slightly in the first cost of the entire plant and the large radiation losses remain unnoticed. Many designers overestimate the importance of keeping the pressure drop in the lines low. Loss of pressure in a pipe line carrying any fluid is due to friction, and results in the transformation of energy of motion of the fluid as a whole into molecular energy or heat. In a water line this heat is usually a total loss, but with steam flowing in well covered pipes most of this heat is carried on with the steam, raising its temperature or its quality. Thus, instead of being able to figure the percentage loss of power as being equal to the percentage of pressure, as is usually true for water or electricity, the loss is materially reduced by the return of the heat to the steam. Or, the total energy of each pound of steam just after entering the pipe is, heat energy + pressure × volume energy + energy of velocity along the pipe.

Before leaving the pipe the heat energy has been drawn upon to increase the volume and also to increase the velocity of the steam, while at the same time the friction has been absorbing a part of the energy of velocity and returning it in the form of heat energy. So, if the pipe could be perfectly insulated all the energy entering the pipe would be delivered at the other end.

CANADIAN PATENTS OWNED BY GERMAN AND AUSTRIAN SUBJECTS.

The following is a list of Canadian patents issued to German and Austrian subjects during August, 1914. For the import of this information our readers are referred to *The Canadian Engineer* for October 29, 1914, page 589. In connection with the following list it is essential to note that the Commissioner of Patents will not void any of these patents, but will grant licenses under the same when the applicant can show that he is willing and intends to manufacture the invention in Canada, and that it is in the interest of Canada, part of Canada, or a particular trade that a license be granted. The applicant will also be required to pay a royalty to the government of probably about 5 per cent. of the selling price of the article.

157216, Aug. 4, 1914—Friction coupling. (Hungary.)

157219, Aug. 4, 1914—Fuse.

157221, Aug. 4, 1914—Type setting and distributing machine.

157236, Aug. 4, 1914—Iron manufacture.

157246, Aug. 4, 1914—Bicycle alarm.

157396, Aug. 18, 1914—Acid converting process.

157402, Aug. 18, 1914—Method of producing chemical reactions in gases.

We are indebted to Ridout and Maybee, Toronto, for the above list.

CAUSES OF BREAKS IN WATER MAINS.

THE annual report of the City of Chicago for 1913 contains the results of an investigation made by Mr. Claude E. Fitch, assistant mechanical engineer, into the causes of breaks in the city's water mains. Many breaks have occurred during past years, but no attempt had been made, until 1912, to discover the cause. Mr. Fitch's findings are very interesting, and are abstracted below. The causes of breaks were ascribed to improper design, poor material, improper handling and installation, soil movements, jarring from traffic, frost, temperature changes, electrolysis, corrosion, excessive static pressure, excessive momentary pressure, periodic pressure waves and extraordinary causes. Explanations of these causes are given as follows:

Improper Design.—For the design of pipe there are numerous formulas giving very nearly the same results, as much the result of experience as theory, and generally considered satisfactory. For the design of valves and special fittings, theory and practice are not so far advanced, but there is not much danger of breaking and such as there may be is more likely to occur at the time the first test is made.

Poor Material.—All reputable builders and nearly all large users employ inspectors who may be reasonably depended on as conscientious in their work. Measurement, superficial inspection, pressure test, hammer test and the breaking of a test bar are the methods usually employed. Chemical tests have their value, but are not so universally used.

Improper Handling and Installation.—A pipe otherwise good may be badly damaged by mishandling in transit or in laying, and thus weakened so as to be unserviceable; or it may be improperly caulked.

Subsidence or Rise of Soil.—Assuming that the pipe has been properly laid, then the soil might be disturbed in one of several ways. Parallel trenches, heavy buildings nearby or the construction of tunnels and subways may so displace soil as to cause leaks or breaks.

Jarring from Traffic.—Where pipes pass through railroad embankments or under street railways or in streets subject to heavy traffic, there is not only displacement of soil from the weights above, but also jars are transmitted to the pipe. Where the displacement is considerable, the danger to the pipes is the same as described in the previous paragraph. The jarring may break a brittle pipe, but the more probable trouble is at the caulking, where the lead is continually deformed by the slight motion, until no longer tight. The resulting leakage causes softening of the soil, making further displacement probable.

Frost.—Under ordinary conditions, this is little to be feared in large mains, as the depth to which the ground freezes in severe winters has been determined by observations extending over many years. Further, the water is scarcely ever below 39 degrees F. in temperature, and if flowing will ordinarily not freeze solid. Troubles from frost are ordinarily confined to smaller mains and service pipes.

Temperature Changes.—The range of temperature of water in mains is not very great, probably 25 degrees, but this is enough to cause a measurable amount of expansion. Expansion or contraction of metals is exerted with great force; almost invariably enough to cause endwise motion of the pipe against the friction of the surrounding soil. This motion is undoubtedly taken up in the more loosely caulked joints, causing them to become more loose and to leak a little. This ability to move slightly at the joints is the reason for the use of the bell and spigot joints, rather than bolted joints.

A more serious phase of this condition may occur at a tightly caulked joint where the cast iron of the bell is first severely strained by the excessive caulking. Should this caulking be done in cold weather, the later expansion of the lead, being several times as great as that of cast iron, may cause sufficient additional strain to rupture the bell.

Electrolysis.—The evidences of damage by electrolysis are generally plain and are likely to be confused only with chemical action due to seepage of corrosive liquids through the soil.

Corrosion.—Pipes are made thicker than is necessary for resisting the physical strains imposed, in order to allow for rusting, and are painted within and without to protect the metal. So far as simple rusting is concerned, a pipe otherwise strong would outlive its usefulness several times in a country of rapid changes. Lead and iron in contact with water or moist earth will cause an electrolytic action on the iron, but experience has shown that this is not a serious matter.

Excessive Static Pressure.—In a small system, relatively new and tight, this might be a source of danger, but in a large system with numerous pumps, engines and mains, much cross connected and with some pipes old and leaky, the danger is not great.

Excessive Momentary Pressure.—Shock, or momentary pressure in the shape of a blow, is one of the most serious troubles to which water mains are subject. Its intensity cannot be calculated with any degree of certainty and therefore it cannot be provided for even approximately in the design. The blow is of the most searching character and is very severe.

Pulsation from pumps is one cause to be considered and may be classed under the head of water hammer. Under this name the effect has been extensively studied.

Periodic Pressure Waves.—Injury from this cause is comparatively infrequent, but may be quite serious, and its way of action is not so easily discovered. Should a pipe receive a set of pressure waves in tune with its natural period of vibration, it will vibrate with increasing force, possibly until it is ruptured, unless stopped by friction.

Extraordinary Causes.—These include explosions and blasting, earthquakes, lightning, intentional injury and possibly the breakdown of a heavy truck above.

An analysis of the list of breaks in Chicago during 1912 showed 42 joint leaks, 3 broken valves and 2 burst pipes. The valves were all three of an ancient type of poor design. No cause was discovered for the bursting of the pipes, although irregular cooling strains were indicated in one case. Of the joint leaks, one was under a railroad embankment and was probably due to the jar of trains and subsidence of the soil. Four were under street tracks where heavier cars have recently been run than previously. A large number were discovered in the spring and early summer after a very severe winter, and temperature changes may have been partly responsible.

But the majority of these leaks were within a mile or so of the Fourteenth street pumping station. This station differs from the Harrison street one only in one pump—the other pumps are exactly similar in the two stations. This pump has twice the rated capacity of the others, a relatively lighter flywheel, and only one air chamber, which is on the pipe line, while the other pumps have a

large air chamber for each plunger. Moreover, the check-valve is placed between the air chamber and the water main. It was therefore concluded that the greater part of the joint leaks were caused by some derangement of the action of this pump, which transmitted pulsations to the mains, possibly assisted by temperature changes and soil movements.

PROPOSED STANDARD SPECIFICATIONS FOR ONE-COURSE CONCRETE HIGHWAY.

THE following specifications have been submitted to the members of the American Concrete Institute to be given their consideration prior to the coming Convention of the Institute to be held in Chicago in February. Many interesting and useful points are contained therein, as indicated below:

Materials.—1. The cement shall meet the requirements of the Standard Specifications for Portland Cement, adopted by the American Society for Testing Materials, August 16, 1909, with all subsequent amendments and additions thereto adopted by said Society, and adopted by this Institute (Standard No. 1).

When the cement is not inspected at the place of manufacture it shall be stored a sufficient length of time to permit of inspecting and testing. The engineer shall be notified of the receipt of each shipment of cement.

2. Fine aggregate shall consist of sand or screenings from clean, hard, durable, crushed rock or gravel consisting of quartzite grains or other equally hard material graded from fine to coarse, with the coarse particles predominating and passing, when dry, a screen having ¼-inch openings. It shall be clean, hard, free from dust, loam, vegetable, or other deleterious matter. Not more than twenty (20) per cent. shall pass a sieve having fifty (50) meshes per linear inch, and not more than five (5) per cent. shall pass a sieve having one hundred (100) meshes per linear inch.

Fine aggregate containing more than three (3) per cent. of clay or loam shall be washed before using.

Fine aggregate shall be of such quality that the mortar composed of one (1) part Portland cement and three (3) parts fine aggregate by weight, when made into briquettes, shall show a tensile strength at least equal to the strength of 1 to 3 mortar of the same consistency made with the same cement and Standard Ottawa sand.

In no case shall fine aggregate containing frost or lumps of frozen material be used.

3. Coarse aggregate shall consist of clean, hard, durable, crushed rock or gravel, graded in size, free from dust, loam, vegetable, or other deleterious matter, and shall contain no soft, flat or elongated particles. The size of the coarse aggregate shall be such as to pass a one and one-half (1½- inch round opening and be retained on a screen having one-quarter (¼) inch openings. In no case shall coarse aggregate containing frost or lumps of frozen material be used.

4. Natural mixed aggregate shall not be used as it comes from deposits, but shall be screened and used as specified.

5. Water shall be clean, free from oil, acid, alkali, or vegetable matter.

6. Reinforcement.—Concrete pavements twenty (20) feet or more in width shall be reinforced with metal fabric. All reinforcement shall be free from excessive rust, scale, paint, or coatings of any character which will tend to destroy the bond. All reinforcement shall develop an ultimate tensile strength of not less than 70,000 pounds per square inch and bend 180 deg. around one diameter and straighten without fracture.

7. Joint filler shall consist of prepared felt or similar material of approved quality having a thickness of not less than ⅛ nor more than ¼ in.

8. Joint Protection Plates.—Soft steel plates for the protection of the edges of the concrete at transverse joints shall be not less than 2½ in. in depth and not less than ⅛ in. at any point nor more than ¼ in. in average thickness. The plates shall be of such form as to provide for rigid anchorage to the concrete. The type and method of installation of joint protection plates shall be approved by the engineer.

9. Shoulders.—Materials for the construction of shoulders shall be approved by the engineer.

Grading.—10. The term "grading" shall include all cuts, fills, ditches, borrow pits, approaches and all earth moving for whatever purpose, where such work is an essential part of or necessary to the prosecution of the contract. When to bring the surface to grade, a fill of one (1) foot or less is required, the area shall be thoroughly grubbed. All soft, spongy or yielding spots and

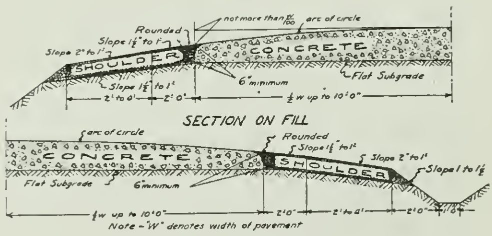


Fig. 1.—One-course Concrete Highway—Sections on Fill and in Cut.

all vegetable or other objectionable matter shall be removed and the space refilled with suitable material.

11. Stakes will be set by the engineer for centre line, side of slopes, finished grade and other necessary points properly marked for the cut or fill.

12. Excess material shall be disposed of as directed by the engineer, the free haul not to exceed.........feet.

13. Over-haul.—Materials hauled a greater distance than the free haul from the place of excavation shall be paid for at the rate of................cents per cubic yard for each additional................feet.

14. Fills.—Embankments shall be formed of earth or other approved materials and shall be constructed in successive layers, the first of which shall extend entirely across from the toe of the slope on one side to the toe of the slope on the other side, and successive layers shall extend entirely across the embankments from slope to slope. Each layer, which shall not exceed one (1) foot in depth, shall be thoroughly rolled with a roller weighing not less than five (5) tons nor more than ten (10) tons before the succeeding layer is placed. The roller shall pass over the entire area of the fill at least twice.

The sides of the embankment shall be kept lower than the centre during all stages of the work, and the surface maintained in condition for adequate drainage. The use of muck, quicksand, soft clay or spongy material which will not consolidate under the roller, is prohibited.

When the material excavated from cuts is not sufficient to make the fills shown on the plans, the con-

tractor shall furnish the necessary extra material to bring the fills to the proper width and grade. When the earth work is completed the cross-section of the road shall conform to the cross-sectional drawings and profile shown in Fig. 1.

15. All slopes shall be properly dressed to lines given by the engineer.

16. Finished Grade.—When grade line is approached, the final grade stakes will be set, for which sufficient notice must be given to the engineer. (In excavating cuts, it is considered advisable, when the line of the sub-grade is approached, to compact the remaining material by rolling. The depth of material left in the cut to be compressed to the finished grade by rolling will depend upon the character of the material.)

17. Drainage.—The contractor shall construct such drainage ditches as will insure perfect sub- and surface-drainage during construction and such work shall be completed to the satisfaction of the engineer, prior to the preparation of the roadbed as herein specified.

Tile drains shall be placed as shown in the drawings attached hereto. Tile to be laid in the trench at least ....(........) inches wide and .... (........) feet deep below the established grade of the finished pavement. Such trench shall be back filled with crushed stone or pit run gravel, with sand removed, which after light tamping shall be ....(........) inches in depth.

Open ditches must be constructed along the concrete road as shown in Fig. 1, the dimensions, side slopes and grade of said ditches being as shown on the cross-section and profile.

At the time of the acceptance of the road, the ditches must be in perfect condition, with clean slopes and bottom, containing no obstructions to the flow of water.

Sub-grade.—18. Construction.—The bottom of the excavation or top of the fill, when completed, shall be known as the sub-grade, and shall be at all places true to the elevation as shown on the plans attached hereto.

The roadway shall be graded to the proper sub-grade to permit of the specified thickness of paving materials being laid to bring the finished surface of the pavement to the lines and grades as shown on the plans.

The sub-grade shall be brought to a firm, unyielding surface by rolling the entire area with a self-propelled roller weighing not less than ten (10) tons, and all portions of the surface of the sub-grade which are inaccessible to the roller shall be thoroughly tamped with a hand tamp weighing not less than fifty (50) pounds, the face of which shall not exceed 100 square inches in area. All soft, spongy or yielding spots and all vegetable or other objectionable matter shall be entirely removed and the space refilled with suitable material.

Where considered necessary or of assistance in producing a compact, solid surface, the sub-grade before being rolled shall be well sprinkled with water.

When the concrete pavement is to be constructed over an old roadbed composed of gravel or macadam, and the concrete is to be wider than the old gravel or macadam road, the latter shall be entirely loosened and the material spread for the full width of the roadbed and rolled. All interstices shall be filled with fine material, and rolled to make a dense, tight surface of the roadbed.

19. Acceptance.—No concrete shall be deposited upon the sub-grade until it is checked and accepted by the engineer.

20. Completion.—Upon the sub-grade thus formed shall be laid the concrete pavement as shown in Fig. 1.

Forms.—21. Materials.—The forms shall be free from warp, of sufficient strength to resist springing out of shape, and shall be equal in width to the thickness of the pavement at the edges. Wooden forms shall be of not less than two (2) inch stock and shall be capped with two (2) inch angle iron.

22. Setting.—The forms shall be well staked or otherwise held to the established line and grades, and the upper edges shall conform to the established grade of the road.

23. Treatment.—All mortar and dirt shall be removed from the forms that have previously been used.

Pavement Section.—24. Width, Thickness of Concrete and Crown.—The concrete pavement shall be...... ......feet wide,............(......) inches in depth at centre, and............(........) inches in depth at the sides. The finished surface shall conform to the arc of a circle, as shown on Fig. 1.

NOTE.—Crown shall be not more than one-one-hundredth (1/100) of the width. The thickness of the concrete at the edges shall not be less than six (6) inches.

Joints.—25. Width and Location.—Transverse joints shall be not less than one-quarter (¼) inch nor more than three-eighths (⅜) inch in width and shall be placed across the pavement perpendicular to the centre line, not more than 35 feet apart. When a curb is specified or where pavement abuts a building a joint not less than one-quarter (¼) inch wide shall be placed between it and the pavement. All joints shall extend through the entire thickness of the pavement and shall be perpendicular to its surface.

26. Protection of Joints.—The concrete at transverse joints shall be protected with soft steel joint protection plates which shall be rigidly anchored to the concrete. The installation of the metal protection plates shall meet with the approval of the engineer. The surface edges of the metal plates shall conform to the finished surface of the concrete, as shown in Fig. 1.

All joints over one-quarter (¼) inch high or one-half (½) inch low shall be removed.

27. Joint Filler.—All joints shall be formed by inserting during construction and leaving in place the required thickness of joint filler which shall extend through the entire thickness of the pavement.

Measuring Materials and Mixing Concrete.—28. Measuring.—The method of measuring the materials for the concrete, including water, shall be one which will insure separate and uniform proportions of each of the materials at all times. A bag of Portland cement (94 lbs. net) shall be considered one (1) cubic foot.

29. Mixing.—The materials shall be mixed to the desired consistency in a batch mixer of approved type, and mixing shall continue for at least forty-five (45) seconds after all materials are in the drum. The drum shall be completely emptied before mixing successive batches. The drum of the mixer used shall revolve at a speed not less than the minimum nor more than the maximum number of revolutions shown in the following table:

Rated capacity, cu. ft. unmixed material.	Capacity, bags of cement in 1 : 2 : 3 mix.	Revolutions per minute of drum. Min.	Max.
7 to 11	1	15	21
12 to 17	2	12	20
18 to 23	3	12	20
24 to 29	4	11	17
30 to 33	5	10	15

30. Retempering of mortar or concrete which has partially hardened, that is, mixing with additional materials or water, shall not be permitted.

31. Proportions.—The concrete shall be mixed in the proportions of one (1) bag of Portland cement to not more than two (2) cubic feet of fine aggregate and not more than three (3) cubic feet of coarse aggregate, and in no case shall the volume of the fine aggregate be less than one-half (½) the volume of the coarse aggregate.

A cubic yard of concrete in place between neat lines shall contain not less than one and seven-tenths (1.7) barrels of cement.

The engineer shall compare the calculated amount of cement required according to these specifications and plans attached hereto with the amounts actually used in each section of concrete between successive transverse joints, as determined by actual count of the number of bags of cement used in each section. If the amount of cement used in any three adjacent sections (between transverse joints) is less by two (2) per cent., or if the amount of cement used in any one section is less by five (5) per cent., than the amount hereinbefore specified, the contractor agrees to remove all such sections and to rebuild the same according to these specifications at his expense.

32. Consistency.—The materials shall be mixed with sufficient water to produce a concrete which when deposited will settle to a flattened mass, but shall not be so wet as to cause a separation of the mortar from the coarse aggregate in handling.

Reinforcing.—33. Concrete pavements twenty (20) feet or more in width shall be reinforced. The cross-sectional area of the reinforcing metal running parallel to the centre line of the pavement shall amount to at least 0.038 square inch per foot of pavement width and the cross-sectional area of reinforcing metal, which is perpendicular to the centre line of the pavement, shall amount to at least 0.049 square inch per foot of pavement length.

Reinforcing metal shall not be placed less than two (2) inches from the finished surface of the pavement and otherwise shall be placed as shown on the drawings. The reinforcing metal shall extend to within two (2) inches of all joints, but shall not cross them. Adjacent widths of fabric shall be lapped not less than four (4) inches.

Placing Concrete.—34. Immediately prior to placing the concrete, the sub-grade shall be brought to an even surface. The surface of the sub-grade shall be thoroughly wet when the concrete is placed.

After mixing, the concrete shall be deposited rapidly in successive batches upon the sub-grade prepared as hereinbefore specified. The concrete shall be deposited to the required depth and for the entire width of the pavement, in a continuous operation, between transverse joints without the use of intermediate forms or bulkheads.

In case of a breakdown concrete shall be mixed by hand to complete the section or an intermediate transverse joint placed as hereinbefore specified at the point of stopping work. Any concrete in excess of that needed to complete a section at the stopping of work shall not be used in the work.

35. Finishing.—The surface of the concrete shall be struck off by means of a template or strike board which shall be moved with a combined longitudinal and crosswise motion. When the strike board is within three (3) feet of a transverse joint it shall be lifted to the joint and the pavement struck by moving the strike board away from the joint; any excess concrete shall be removed. Concrete adjoining the metal protection plates at transverse joints shall be dense in character and any holes left by removing any device used in installing the metal protection plates shall be immediately filled with concrete.

After being brought to the established grade with the template or strike board, the concrete shall be finished from a suitable bridge, no part of which shall come in contact with the concrete. The concrete shall be finished with a wood float in a manner to thoroughly compact it and produce a surface free from depressions or inequalities of any kind. The finished surface of the pavement shall not vary more than one-quarter (¼) inch from the true shape.

The edges of the pavement shall be rounded as shown in Fig. 1.

Curing and Protection.—36. Excepting as hereinafter specified, the surface of the pavement shall be sprayed with water as soon as the concrete is sufficiently hardened to prevent pitting, and shall be kept wet until an earth covering is placed. As soon as it can be done without damaging the concrete, the surface of the pavement shall be covered with not less than two inches of earth or other material which will afford equally good protection, which cover shall be kept moist for at least ten (10) days. When deemed necessary or advisable by the engineer, freshly laid concrete shall be protected by a canvas covering until the earth covering can be placed.

It at the time the pavement is laid or during the period of curing the temperature during the daytime drops below 50 degrees Fahrenheit, sprinkling and covering of the pavement shall be omitted at the direction of the engineer.

Under the most favorable conditions for hardening, in hot weather, the pavement shall be closed to traffic for at least fourteen (14) days, and in cool weather for an additional time, to be determined by the engineer.

The contractor shall erect and maintain suitable barriers to protect the concrete from traffic, and any part of the pavement damaged from traffic or other causes occurring prior to its official acceptance, shall be repaired or replaced by the contractor at his expense in a manner satisfactory to the engineer.

Before the pavement is thrown open to traffic the covering shall be removed and disposed of as directed by the engineer.

37. Temperature Below 35 Degrees Fahrenheit.—Concrete shall not be mixed or deposited when the temperature is below freezing.

If at any time during the progress of the work the temperature is, or in the opinion of the engineer will within twenty-four (24) hours drop to 35 degrees Fahrenheit, the water and aggregates shall be heated and precautions taken to protect the work from freezing for at least ten (10) days. In no case shall concrete be deposited upon a frozen sub-grade.

Shoulders.—38. Construction.—Where shoulders are required they shall be built upon the properly prepared sub-grade, as shown on the cross-sectional drawing, Fig. 1. The work shall be done to the entire satisfaction of the engineer.

ADDITIONAL POWER FOR KINGSTON, ONT.

The Public Utilities Commission is considering an offer from the Gananoque Electric Light and Power Company for the supply of a large block of power, presumably from the development at Kingston Mills on the Rideau. Mr. F. A. Gaby, chief engineer of the Hydro-Electric Power Commission of Ontario has been consulted regarding the technical features of the proposition. At present the Kingston Street Railway Company consumes 51 per cent. of the city's existing output, which it obtains at a rate of 1 2-5 per k.w. hr.

USES FOR POWER FROM IRRIGATION DAMS.*

THE question may be asked, What is the best use to make of electric power which is developed by water for irrigation? Irrigation dams are usuolly situated at considerable distances from cities and other centres where electric current is wanted for lighting, tramways, and motive power. Although electric transmission of power is efficient, a long distance transmission line is expensive to construct and maintain, and even in countries where there is no trouble with ice and snow, there are the risks of stoppage due to wind and dust storms, bush fires, etc.

When estimating the supply available from a given source for domestic purposes, only the minimum flow can be reckoned upon, if risk of shortage is to be obviated. Therefore, for a domestic supply of electricity all surplus between the minimum and the maximum flow is wasted, so far as power is concerned, and expensive spill-weirs and channels have to be provided.

Clearly, it is wise to make use of the electric power as near to where it is generated as possible, also for operations which use the same power right through the 24 hours, but which can be temporarily suspended if need be.

When the Assuan dam comes to be harnessed a part of the power is to be transmitted about 30 miles and used for pumping. Assuan presents considerable difficulties, because, in the first place, it is not easy to select an industry to be pursued which could utilize power that varies between 100,000 h.p. and 10,000 h.p.; also during the greater part of the year the climate at Assuan is extremely hot, and it is, therefore, difficult to develop large manufacturing industries in such a climate.

When the Trawool dam scheme was being considered a suitable use for the power appeared to be to transmit it to the cities of Ballarat, Bendigo, and Melbourne for a domestic supply. The great advances of the last few years of electro-chemistry and metallurgy have, however, changed the situation considerably. During this period of eight years many new industries which utilize large quantities of cheap electrical power have safely passed the experimental stage, and a single factory making fertilizers could now easily utilize the entire output of the water power, and with an absolute certainty of selling the product without disturbing prices. The tendency is now to establish electro-chemical and metallurgical factories close to the power, and to dispense with transmission lines; also to work the water power and the factory together, arranging the output of the one to meet the demand of the other so that the utmost use can be made of the water available. When that is done surplus water need not be wasted, and under certain conditions the whole mean annual rainfall may be reckoned upon after allowing for evaporation.

The following are some of the new electrical industries which require large quantities of electrical power at low cost: (1) Manufacture of nitric acid from atmospheric nitrogen in electric furnace by the direct method. (2) Making nitrogenous and phosphate nitrogenous fertilizers by the direct process. (3) Manufacture of calcium carbide for acetylene lighting. (4) Manufacture of calcium cyanamide fertilizer from calcium carbide. (5) Electric reduction of iron and steel. (6) Making alkali from salt by the electrolysis. (7) Making aluminum from bauxite. (8) Making carborundum for use as an abrasive. (9) Making graphite in the electric furnace. (10) Melting concentrates. (11) Treating refractory zinc ores, etc.

Some of these industries have to be carried on continuously, as, for example, the manufacture of calcium carbide and calcium cyanamide, the reduction of iron and steel, and the making of aluminum, etc. The cost of stoppage and restarting is excessive in all smelting and allied operations. On the other hand, some of the industries, such as fixation of atmospheric nitrogen by the direct process, can be worked intermittently. The manufacture of graphite can also be carried on intermittently.

Where the water can only be used for a portion of the year, the problem is to fix upon some particular industry which can utilize power intermittently, and will permit of changes in the amount of labor employed, without undue additional expense. Also, the product must be such that it has a widespread market, so that when it is turned out in considerable quantities it does not upset prices. At the same time it should be capable of being conveniently stored at times when the output may temporarily exceed the demand. The manufacture of fertilizers from atmospheric nitrogen by the direct furnace process meets all these conditions, and is, therefore, ideal. Not only can the process be carried out intermittently, but the demand is practically unlimited, for to be continuously productive all soil requires plant foods. The most direct and simple method to make fertilizer is to blow air through an electric arc flame so as to form nitric oxide gas. In the presence of oxygen this changes to nitrogen peroxide, which, when brought into contact with water, produces nitric acid. If lime is acted on by this dilute nitric acid a nitrogenous fertilizer called calcium nitrate, containing 12¾ per cent. of nitrogen, is produced. Large quantities of this fertilizer are made in Norway, and it is finding its way to the fruit lands of California and to other parts of the Pacific in competition with sodium nitrate and sulphate of ammonia.

A valuable fertilizer can be made by grinding up phosphate rock and mixing it with water to the consistency of cream. When the gas from the furnace is passed through this it changes the phosphate into the citric soluble state, so making it valuable as phosphate fertilizer. At the same time the lime is acted upon and takes up nitrogen, so that the fertilizer contains two out of the three principal plant foods. The phosphate of basic Bessemer slag is in the soluble condition, and is very largely used as a phosphate fertilizer, but the slag from some open-hearth steel furnaces is largely insoluble, and so the phosphate is not in a form in which it is immediately available for agriculture. This waste basic slag is being produced in Middlesborough alone at the rate of 150,000 tons a year. With the aid of the electric furnace it may be possible in the future to turn it to good account. The direct method of making fertilizers has reached enormous proportions in Norway. One factory utilizes 140,000 h.p., which is generated by a water-power at Rjukan, while another factory to utilize 120,000 h.p. is being equipped. About $40,000,000 is invested in the business in Norway alone.

* Abstracted from a paper by E. Kilburn Scott before the British Association, Australian meeting, August, 1914.

Mayor H. C. Hocken, of Toronto, and several of the officials of the works department will represent the city at the fifth American Good Roads Congress in Chicago this week.

The MacArthur Concrete Pile and Foundation Company has appointed the Douglas Milligan Company as their sales agents for Eastern Canada, with main office in the New Birks Building, Montreal, and branch office at 95 King Street East, Toronto.

NEW ASPHALT PLANT AT MONTREAL.

By Daniel J. Hauer, C.E.

THE need of the proper kind of a modern asphalt plant in many Canadian cities has been made very evident to the writer in his visits to the eastern part of the Dominion during the past few years. The newest municipal asphalt plant recently put in use in Montreal is therefore of interest, and admits of the following description:

Tenders were submitted to the city upon plans and a general arrangement specifying size and capacity, together with a set of specifications showing the quality of materials, etc., gotten up by the chief engineer of Road Department of Montreal. The contractors had to design the building and plant, also provide a set of specifications for the building and machinery, all of which were to be approved by the city. The successful bidders for the job were Warren Bros. Company, of Boston, Mass.

The Building.—The plant is located in the Road Dept. yard in the north end of the city. The building, as shown in Fig. 1, is built of structural steel with corrugated sides and roof. The main part of the structure is of two stories with a tower on each end of an additional story for the hot storage bins for sand and stone. In the rear, in a 1-story addition, is the boiler and engine room. The windows in this room are ordinary in type, while in the rest of the building they are of corrugated steel, each opening as a shutter.

The lower floor has a concrete pavement in it. The second story has a reinforced concrete floor designed to carry a dead load of 400 lbs. per sq. ft. with a factor of safety of 4. This floor is intended for storage of limestone dust and asphalt. The third floor is of similar construction, but the dead load figured for it with the same factor of safety is 200 lbs. per sq. ft. The roof is designed to carry a snow load of 40 lbs. per sq. ft., with a safety factor of 4. The corrugated iron used on the sides of the building is No. 24 gauge and on the roof No. 22. The entire lower story is open, allowing easy transit for men and teams.

Arrangement of Ground Floor.—In the centre of the first story is located 5 asphalt melting tanks or kettles, provided with air agitation, each of a working capacity of 2,000 Imp. gal. Two of these tanks are of the enclosed pressure type and three are open, all being connected at the bottom with a 3-inch pipe line, by means of which the contents of any of the open tanks may be drawn by suction into either of the pressure tanks, with suitable connections in the air compressor so that it may be operated as a vacuum pump to accomplish this purpose. On the second floor a 3-inch pipe runs from the pressure tanks to the asphalt weighing buckets at both mixers, thus feeding the asphalt by air.

The melting tanks are encased in brick and each has an independent fire-box for heating purposes, the bottom of the tanks being protected from burning by fire brick. The fire-boxes are constructed for coal consumption. There is an independent smoke stack for these tanks.

Fig. 2 is a view of the lower floor and shows these melting kettles. In the foreground is the driveway under the binder mixer and at the other end of the building is a similar driveway under the topping course mixer. These two driveways can be seen better in Fig. 1. To the rear of the melting tanks are located the drying units, consisting of 2 Warren standard 40-inch sand dryers and a single binder dryer. Each sand dryer has independent settings, but are coupled together with the same driving gear. Each dryer is fed by an independent bucket elevator. The stone and sand are brought to the plant in cars or wagons and dumped near the building, where it is picked up by the elevators and fed directly into the drying units. The revolving cylinders are 19 ft. 8 in. long and the dryers are so constructed that the material passes through them by gravity instead of being forced through by spirals. These dryers are so arranged with induced draft, so that the flames and hot gases pass the full length of the dryer on the outside of the revolving cylinder and return through the inside before being taken out by the fan. In the cylinders longitudinal vanes are provided that lift the materials being dried to the top of the cylinder, dropping it as the latter revolves, through the hot gases being drawn through it by the exhaust fan.

This induced draft is supplied by a 50-inch steel plate exhauster, provided with a Cyclone dust collector to separate from the exhaust the fine particles of sand, thus preventing the sand from being discharged into the air. Each dryer has a fire-box 3 ft. 8 in. wide and 10 ft. 6 in. long, giving an extremely large grate surface, providing a low rate of combustion of fuel and obtaining the full capacity of the dryers, without unduly forcing the fires.

The revolving cylinders are supported at either end by heavy 6-in. x 12-in. Universal bearings, the rear bearings being fitted with thrust collars to take care of the expansion and contraction of the cylinders.

Fig. 1.—Exterior of New Municipal Asphalt Plant of Montreal.

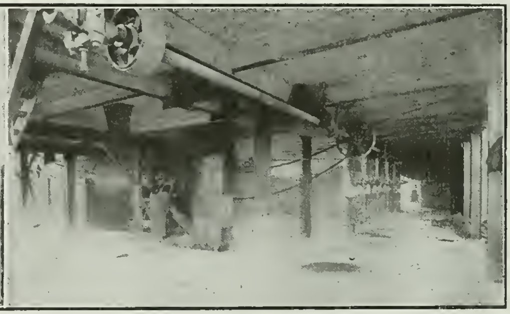


Fig. 2.—View of Ground Floor.

The binder dryer is of similar type and size but using only a 40-inch steel plate exhaust. The exhaust gases from the dryers are carried off in stack from the dust collector.

The dryers discharge their contents by gravity into boots below the level of the floor, from which the hot material is carried by enclosed elevators to the hot bins on the third floor in the towers. The elevator shown in Fig. 2 is that for the binder, while beyond the melting tanks is located the one for the hot sand. The spout projecting through the concrete floor in the illustration is the bottom of the rejection bin, which serves as a storage reservoir for the rejection, when running topping, so that they may be hauled away without creating a nuisance around the plant.

The screens for the materials are located over the hot bins in the towers. All the shafting for operating the plant is on the ground floor.

Power Plant.—The power plant (see Fig. 1) consists of a horizontal tubular boiler 66 ins. by 14 ft. in a brick setting, and has a stack 40 ft. high. The boiler is equipped with an injector and a boiler feed pipe, also a 100-h.p. open feed water heater for heating the boiler feed water. The engine is built by the Goldie & McCulloch, Company,

Fig. 3.—View of Second Floor.

Limited, of Galt, Ont. It is an enclosed engine of the automatic cut-off type, 13 x 12 in. stroke and equipped with the splash oiling system.

A 6 x 10 x 8 in. Clayton fly-wheel compressor, capable of compressing 80 cu. ft. per min., makes up the equipment in the engine room. The piping of the air system is so arranged as to be able to run the pump as a compressor or as a vacuum pump, as the requirements dictate.

Hot Bins and Towers.—The hot bins, as already stated, are located in the towers. These bins are of steel and have a capacity, level full, of 10 cu. yds. These bins serve the mixers. Each bin is provided with a rotary sand screen 30 in. in diameter, having an effective screening surface of at least 3 lin. ft. of 8-mesh iron wire cloth made of No. 20 gauge wire. Each screen is so arranged that when it is desired to run binder from either of the mixers the stone may be discharged directly into the bin without passing through the screen. The top of each bin is covered with light steel casing to retain the heat in the material and to confine the dust to the bins.

Arrangement of Second Floor.—The interior of this floor is shown in Fig. 3, as standing alongside of the topping mixer and looking towards the binder mixer. Ample room is provided for storing the bags of limestone dust and barrels of asphalt. The plant is equipped with two elevators for carrying these materials to this floor. These can be seen in Fig. 1, the continuous bag elevator on the right and the continuous barrel elevator on the left.

In the centre of Fig. 3 can be seen the tops of the 5 melting tanks and the asphalt feed pipe running towards the two mixers.

The two mixers are of Warren 9 cu. ft. type, capable of mixing economically batches of 1,000 lbs. of topping mixture and 1,100 lbs. of binder mixture. The drive of this type of mixer is furnished with a jaw clutch, so as to throw it out quickly in case of an accident. The bottom of the mixer is fitted with sectional reinforcing lines made 3/8 in. thick to take the wear and tear off the mixers. One mixer is equipped with topping teeth and the other with regular binder teeth. The mixers discharge by means of a sliding gate through the floor into wagons beneath.

A limestone dust bin of 2 cu. yd. capacity is provided with each hot material bin so that topping may be run from either mixer as desired. The dust is fed into the hot sand weigh-box by means of a screw conveyer operated by a friction clutch controlled by the weigh-box attendant. A separate elevator is used for placing the dust in the bins.

Each mixer has an asphalt weighing-bucket mounted on a carriage running on an overhead track with scales that automatically weigh the bucket full and empty.

The weigh-box at each mixer has a capacity of 12 cu. ft. This box is filled from the hot bins by an orifice with a swinging cut-off gate. The weigh-box rests on platform scales and discharges its contents through a gate in the front, by gravity, into the mixer. A by-pass in the tray allows of rejected material being dumped into a reservoir, as previously stated. The scales used for weighing are of such a type that each batch of material is weighed without the necessity of calculation, and so that the proper charge of limestone can be weighed with the sand.

A flux-weighing tank having a capacity of 300 gal. is also provided, resting upon a 3,000-lb. platform scales, constructed to balance the tare and give the weight of the oil by direct reading.

The main drive from the engine is an oak-tanned triple extra leather belt. The drives from the main shaft to the elevator countershaft are of double extra leather. The drives from the main shaft to the mixer driving shafts are silent chains. Those to the dryers are of steel bush roller chains, while the rest of the drives are detachable link belting. The entire plant is interchangeable and can be used for binder and topping, or can be used for topping alone. When the two classes of materials are run the capacity of the plant is 2,000 sq. yd. of finished pavement per day, while if the plant is run on topping alone it will produce 3,000 sq. yd. 2 inches thick.

This plant is, in consequence of this output, the largest asphalt plant in the Dominion, and is one of the largest municipal asphalt plants in use anywhere.

This is the third plant built by these contractors for the city of Montreal. The first plant built was in the east end, the second in the west end of the city. Both of these plants are still in operation, the first one being built in 1903 and the second one in 1907.

The north end plant is a modern and economical one. Similar plants with smaller capacity can be built by decreasing the units and their size. It is economy to have a well-designed plant rather than a makeshift, and the money so expended will earn a handsome dividend over using a poorly designed and constructed plant in the cost of operation alone, not considering the quality of the pavement laid.

COPPER AND THE WAR.

THE world's production and consumption of copper have been seriously interfered with by the war, and prices are very unreliable, as no one can foresee, at the moment, the probable demand during the immediate future, nor the length of the war. The world's production of copper during recent years has been as follows:—

	Tons.		Tons.
1913	1,005,900	1911	893,800
1912	1,018,600	1910	891,000

More than 50 per cent. of the total is produced in the United States. It is noteworthy that although the United States output largely exceeds the United States consumption, copper is, nevertheless, imported. Thus, during October 475 tons of slabs were imported from Japan and 690 tons of pig copper from Peru.

Copper was produced last year in the following countries: Mexico, 90,000 tons; Japan, 77,200 tons; and Australia, 41,800 tons. As regards Europe, German and Austrian output was the largest, the quantity being 52,100 tons, out of a total European output of 186,500 tons. Great Britain is second, with 41,100 tons; then Russia, 34,300 tons; and Spain with 23,600 tons. European consumption during 1913 reached 643,100 tons; after allowing for the European output, 456,600 tons had to be imported, obviously mainly from America. The European consumption was as follows: Germany, 259,300 tons; Great Britain, 140,300 tons; France, 103,600 tons; Russia, 40,200 tons; Austria, 37,200 tons; Italy, 31,200 tons. The United States consumption reached the enormous quantity of 351,000 tons.

Reduced consumption has necessarily resulted in reduced production; the world's copper output, now that curtailment has become effective, has dropped, according to very competent expert opinion, to a basis of about 500,000 tons per annum.

The world's consumption of copper over a term of years has been as follows, in tons:

	1913.	1912.	1911.	1910.
England	140,300	148,877	159,736	148,187
France	103,600	106,753	106,408	92,838
Russia	40,200	38,818	31,830	28,237
Germany	259,300	253,429	234,985	208,826
Austria	37,200	51,574	41,101	37,150
Italy	31,200	34,378	40,949	32,487
United States	351,000	365,922	316,791	334,565

The copper exported from America, practically all to Europe, during the nine months of the year and the corresponding months in the preceding four years has been as follows:

	1914.	1913.	1912.	1911.	1910.
January	35,566	24,659	30,967	29,357	26,699
February ...	34,384	26,767	35,418	18,992	25,238
March	46,504	42,428	27,074	23,200	19,963
April	34,787	33,024	23,341	27,466	31,062
May	31,948	38,251	32,984	26,655	20,832
June	35,182	27,808	26,547	30,074	23,430
July	34,145	29,096	25,445	34,955	22,875
August	19,676	34,722	29,526	27,893	27,876
September ..	16,838	34,314	25,572	25,745	31,733

These figures distinctly indicate the effect of the war during August and September on the world's copper markets.

Towards the end of September, a noteworthy feature of the copper market was the action of the British Government in acquiring all the stocks of copper carried in Dutch warehouses, as this metal almost always is destined for Germany. Three cargoes of copper afloat for Holland were also taken by the British Government. It is reported that the German Government has followed the lead of the British Government in the compulsory acquirement, and paying at prices fixed by the British Government, of all stocks of copper stored in Rotterdam warehouses, and captured afloat in neutral vessels, belonging to American companies. Considerable stocks of copper are stored in Germany belonging to American owners; the German Government has confiscated them, and is paying for them in precisely the same terms as those fixed by the British Government.

We are indebted to Engineering (London) for the information.

GOVERNMENT GRAIN ELEVATOR AT VANCOUVER, B.C.

The contract for the new Government grain elevator at Vancouver has been awarded to Barnett & McQueen, whose headquarters are in Minneapolis, Minn., with a branch office at Fort William, Ont. The construction of this elevator, the contract price for which is $690,000, will practically complete the government's chain of interior and terminal elevators extending across Canada between Port Arthur and the Pacific Coast. The elevators included in this system are: One at Port Arthur for eastbound grain, the proposed elevator at Vancouver for Pacific trade, and three interior elevators at Moose Jaw, Saskatoon and Calgary. In this connection might also be mentioned the elevators of the Montreal Harbor Commission, which are now under the control of the Western Grain Commission in many respects. It is also likely that an elevator, for terminal purposes, will eventually be constructed at Port Nelson for the Hudson Bay route.

The Vancouver elevator is to be of reinforced concrete. It is to have a storage capacity of 1,250,000 bushels, 300,000 of which will constitute the capacity of the working house, and 950,000 of the storage building proper. The design shows 52 circular storage bins in the latter, and 32 in the former. The storage building is further equipped with 32 interspace bins. It is to be 232 x 71 ft. The working house will be 126 x 62 ft. and, in addition to the 32 circular bins, there will be 21 interspace and 15 outerspace bins. The elevator buildings will also include a sacking plant and transformer house. These will be housed in one building 62 x 25 ft. The adjoining track shed is to be 150 ft. 8 in. long x 52 ft. wide. The wharf on Burrard Inlet will accommodate seven lines of tracks, and there will be also five tracks between the wharf and the Canadian Pacific Railway line. Three car ways will lead to receiving hoppers, each hopper with a capacity of 2,000 bushels. In all, there will be nine of these hoppers. Outgoing grain will be loaded on vessels by two-belt galleries, one on either side of the wharf. The sacking plant will include two sets of automatic sacking scales, each scale with a hopper capacity of from 2 to 6 bushels, and capable of weighing 1,500 bushels an hour. The power equipment will consist of forty 60-cycle, 3-phase, alternating current motors, aggregating 1,520 horse-power.

It will be noticed that the above elevator will resemble in many particulars those now in operation at Port Arthur, Saskatoon, Calgary and Moose Jaw. It is expected that the structure will be completed in November of next year.

HYDRAULIC PLANT, JOLIETTE, QUE.

A VERY interesting pumping plant is now in the process of construction in the town of Joliette, on the Assumption River. Fig. 1 shows the general layout. This includes a solid concrete overflow dam about 230 ft. in length, and varying in depth from 5 to 7½ ft., tapering from a width of 2 ft.

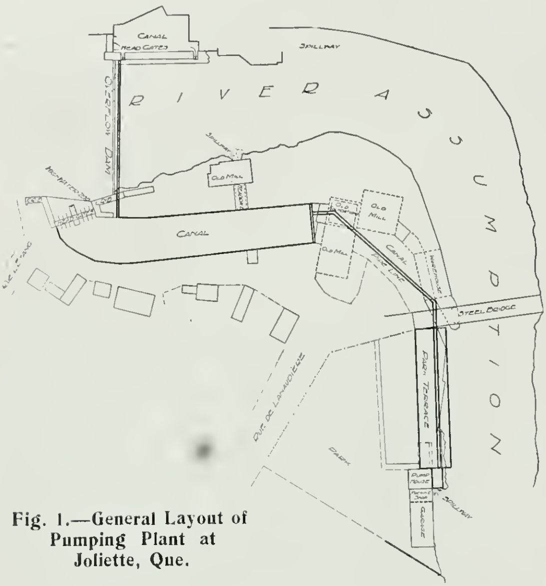


Fig. 1.—General Layout of Pumping Plant at Joliette, Que.

at the top to 11 ft. at the base. West of this structure the head gates admit water into a canal, the sides of which are of concrete retaining construction, and are terminated by a solid concrete head wall with an entrance to a stave flume 6 ft. in diameter and about 400 ft. long. The power house, also of reinforced concrete construction, contains a double Francis turbine of 200 h.p., carrying a horizontal shaft to which are belt-connected two centrifugal pumps, each with a capacity of 1,500 Imperial gallons per minute when working in parallel, and providing water at 65 pounds per square inch pressure. The drawing also shows a reinforced concrete platform 210 ft. long and 40 ft. in width, running parallel to the river, and to be used for pleasure purposes. Buildings indicated by dotted lines on Fig. 1 show the position of buildings, the demolishment of which is being necessitated by the new development.

Fig. 2 shows a section of the dam. It shows anchor bars 1¼ in. in diameter, which are staggered the entire length of the dam in planes 4 ft. 9 in. apart, the rods having a longitudinal spacing of 12 ft.

The wood stave pipe 6 ft. in diameter, is joined with steel sections. Two pronounced angles are encountered in the alignment of the conduit. The pipe is supported on concrete pedestals placed 8 ft. c. to c. and resting on rock foundations. These supports are to be 12 in. in thickness, and 6½ ft. in length at the top with a gentle taper. The lower end connection of the pipe is shown in plan and elevation in Fig. 3.

The terrace has been designed in reinforced concrete supported by pillars 17 ft. c. to c., resting on rock foundation. An artistic arch construction will be accompanied by reinforced concrete railings and ornamental lighting standards. The park side of the terrace provides three approaches by concrete

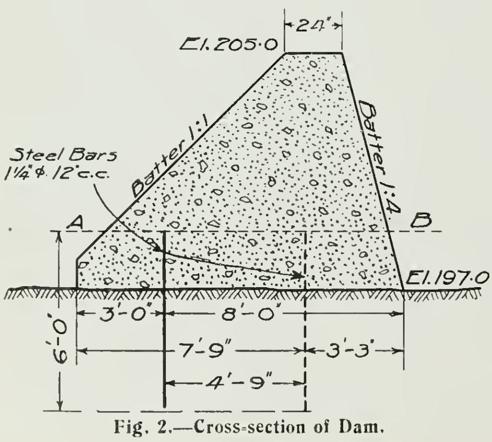


Fig. 2.—Cross-section of Dam.

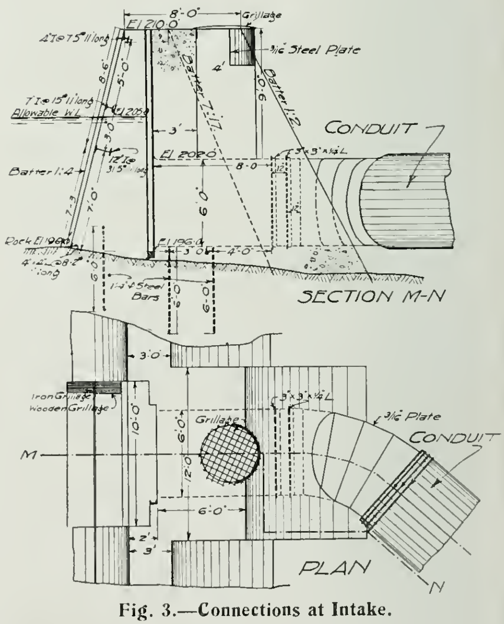


Fig. 3.—Connections at Intake.

steps. A section of the supporting piers, showing also the location of the conduit, is given in Fig. 4. The terrace provides 39 columns 14 in. x 14 in. in section reinforced by ¾-in. steel rods placed longitudinally and varying in length from 8 to 11 ft. The floor slab is 6 inches thick and the beams and girders are 20 and 28 inches deep, reinforced longitudinally with Kahn bars.

At the south end of the terrace will be situated the pumping plant, of reinforced concrete construction on

rock foundation. The turbine chamber into which the water enters from the conduit is 12 ft. x 9½ ft. The water leaves the turbine through an 8-ft. vertical draft tube tapering from 4 ft. 5 in. in diameter at the turbine end to 5 ft. The tail race projects beneath the floor of the building directly to the river bank. This flume is also of reinforced concrete construction.

To the turbine shaft is direct connected a fly wheel 8 ft. in diameter with belt drive to the floor above, where the two 1,500-gal. centrifugal pumps are installed. The general arrangement of this is shown in elevation in Fig. 5.

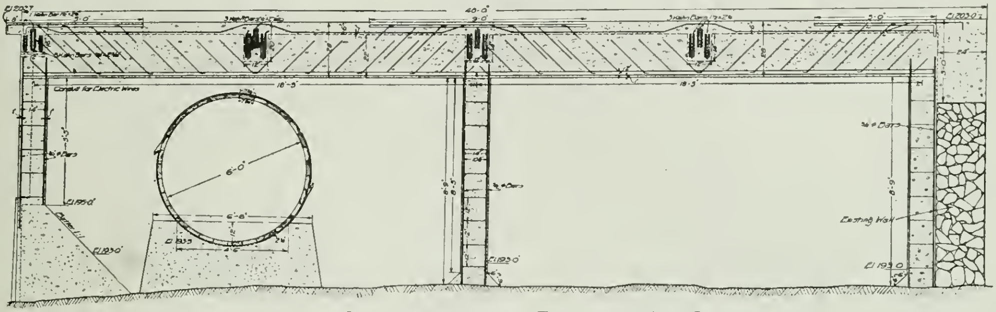


Fig. 4.—Cross-section of Park Terrace and Pipe Line.

The general contract for the development was let to Messrs. Arsenault and Planondon, engineers and contractors, Montreal, for $32,516. Escher Wyss & Company are supplying the machinery, the price being $5,155. Surveyer and Frigon, civil engineers, Montreal, have charge of the development.

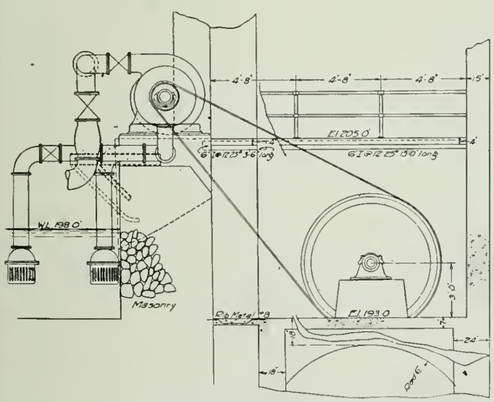


Fig. 5.—Pumping Arrangement.

Wood paving block is specified as one of five kinds of paving that may be laid in Honolulu streets. Approximately 100,000 Douglas fir blocks have been laid in the city. The size of block that is thought best adapted is 3 by 4 by 4-in. A bid submitted by a contractor during the middle of October, 1914, named $1.962 per square yard for Douglas fir blocks, furnished and placed, including foundation. The price bid was lower than in some previous tenders. Ohia also has been used for paving block and, being a native wood, has probably been favored. No large amount of wood-block paving remains to be done in Honolulu, but much will be done in the future in the next largest city, Hilo.

NOTES ON MINING ACTIVITIES.

In commenting upon the effects of the war upon mining, a contemporary states that they are not all harmful. The lack of employment in the copper fields has induced copper miners to invade gold and silver-producing districts to lease and to begin operating. Prospecting, too, has received quite a boost.

"This," states the writer, "must result in much good to the mining industry. The work of prospectors will result in new mines and the opening up of new opportunities for investors. The working of leases means greater development and more extensive mining operations. The man who takes a lease and succeeds—that is, makes good money for himself—is pretty sure to continue in independent mining. The more independent successful miners there are in a camp the livelier and more prosperous the camp." There has been a serious lack of prospecting during recent years and if the war will have the effect outlined above it will be a benefit, no doubt, to mining. When general business and industrial conditions recover from the effects of the disturbance caused by the breaking out of the war mining should find itself in a better position than it would have been had the war not occurred. There should be an increased demand for the products of the mines, not only to supply the needs of Europe, but to meet increased demands of domestic industries, and mining should prosper.

According to the Labor Gazette, the mining industry, however, is fairly active in this country. In November the collieries at Sydney Mines were running full time. The Dominion collieries were reported as not quite so busy, though they had a fair amount of work. Other collieries in coal mining districts in Nova Scotia were fairly active. In some of the western mines the delay in the advent of cold weather rendered conditions somewhat inactive. At Nanaimo the mines were working to full capacity, though some of the mines in the adjacent districts were not working full time.

In metal mining, operations in the Cobalt district came back to normal, and at the month's close very few men in the camp were out of work. At Porcupine the Hollinger mines increased their force and had about 1,000 men employed. Some reductions were reported in the staff in the iron mines at Michipicoten.

Heavy shipments of ore were reported from the Rossland mines to the Trail smelter, and the larger output of the mines in the district and the increased numbers at work were having the effect of renewing activity in business at Rossland.

EFFICIENCY OF HIGHWAY ORGANIZATION.*

By Col. E. A. Stevens,
State Highway Commissioner of New Jersey.

THE very size and the commercial importance of the highway problem make efficiency necessary to a fully successful solution. To-day we can state the problem in general terms only. Even the total mileage of roads and what portion of them have already been improved are only approximately known facts. There is to-day no need of arguing the necessity of good roads. The questions to be answered are: Where will the roads to be built be located? What will they cost? How are we to insure that, once built, they will give us the service for which they were built, and for which the people are paying? In all of this how are we to insure that the man who pays the bill is not to be taxed more than need be, that he gets value received for every dollar expended?

It would be a foolish man who would undertake to dig the cellar and lay the foundation for his house without first deciding how much room he needed to house his family; how much he could afford to spend therefor; how he is to meet the cost of housekeeping, repairs, insurance, and taxes; and finally how all this is to be done without waste.

In such a case, it is easy to see the need of some forethought. In the much larger problem of providing good roads, the very immensity of the quantities and costs, and the difficulty of gathering the data necessary to state them with approximate accuracy, or the failure to realize the importance of this knowledge, seems to have prevented preliminary study. We have in general tackled the problem with a view limited to a solution over a very narrow field. Since we took up the subject, the problem of administration, design, and construction, have been changed by motor traffic. This traffic has made the road a matter of general and not of local interest; has shown us that hitherto approved methods of construction are no longer generally available, and that systematically organized methods of caring for our roads and of raising our road funds are at least worthy of our most careful thought.

Let us, therefore, look at our problem for a moment without worrying about what others have done. The best way of doing the job is still an unsettled question. On whom shall we place the burden of arriving at the best method? Taking John Fritz's quip that "an engineer is the man who can do with one dollar what any fool can do with two," it is clear that that sort of an engineer is the man we want. Without a force properly drilled in the work, and properly organized to do it, efficiency, the getting for one dollar what with waste will cost us two, is impossible. With such a force, money and time spent in careful preliminary study, in being sure we are right before we go ahead, will not be wasted.

We need, first, a force that can lay out a well-thought-out plan with a fair chance to do so without political meddling. The cost can then be forecast. Changes in traffic may lead to changes in general design and detail without making efficiency impossible. The same happens so often with even so simple a task as building a house, that the wise man always allows some margin on the first detailed estimate of cost. With the cost known, plans for raising money can be made for meeting it, and a program of construction arranged with a view of giving the earliest and greatest return for the money spent.

Bond issues and the "pay-as-you-go" plan must be considered. It is evident that over any period for which bonds are issued, the tax levy must include interest and amortization charges on the bonds, as well as the cost of caring for the roads built, and to meet depreciation. If the same amount be raised each year by taxation and used to meet road-building, repair and depreciation charges, it is clear that the amount raised for interest and amortization, and, in the first part of the period, some of the amount raised for repair, etc., can be used for new work. The net result over the whole period is a reduced cost for a given mileage. Against this we have the use of the roads built for a longer average time. This benefit will, in many cases, be cheap at the increased price, but only on the assumption that bonds are issued on some definite and business-like plan, and the proceeds wisely invested. This has not always been the case.

Any satisfactory road administration must provide for proper design. The data for this is not readily at hand. Traffic figures over an unimproved road bear no relation to the traffic to be expected after improvement. Even were satisfactory traffic data readily available, the economic values of different types of construction are unknown. Motor traffic for not over ten years has been a serious destroyer of road surfaces. It is increasing yearly in intensity. The surfaces specially designed to carry this troublesome and valuable load have not been in use long enough to determine their probable lives and cost of upkeep under the conditions of to-day. The cost of the road is a yearly one, and must include depreciation, if the waste of road material is not made good every year. Therefore, it may well be cheaper to spend money in the repair of a cheap type, such as macadam or gravel, rather than to resurface with an expensive pavement pavement whose life is at the best uncertain.

For example, a macadam road under heavy traffic may be maintained at about the following cost per square yard:—

	Cents.
Stone, say, ½ in. or 42 lbs. at \$3 a ton rolled in place	6.3
Bituminous binder, say, ⅜ gal. at 15 cents, spread and covered	5.6
Ditches and drains, say	1.0
	12.9

If an improved type of surface is laid on the old macadam at a cost of, say, \$1.25 a yard, the annual charge to be seen in the tax levy will for some years be merely the cost of ditch and drain work and a small amount to care for imperfections. The community might, however, have used the \$1.25 for new work, or might have left it with the taxpayer; in either case, it is costing the interest which, at 4 per cent., is 5 cents. We have, then, a saving of 6.9 cents, but it seems fair to assume that over a life of from 10 to 20 years we should allow at least 0.9 cent for repairs. Our saving is then 6 cents. We would have to realize this saving for about 21 years to get back our \$1.25, and if the new surface lasts less than that period it may well prove wasteful.

But any such figures are of academic interest only, unless we have the organized repair force needed to keep our roads in repair and a system of accounting that will give accurate data and that is based on an outlook over a period somewhat longer than that covered by next year's tax bill. On the basis of such a system and with

* Read at Fourth American Road Congress, Atlanta, Georgia, November 9th to 14th, 1914.

such a force are our railroads operated. Their problem is of the same kind as ours—a matter of cheap and efficient transportation. It is, perhaps, curious that while the tendency of the day is to regulate these and other public service corporations as to the safety and adequacy of their service, and as to their methods of financing, the people of this country have in no case insisted on such safeguards as to the work of those entrusted with their roads.

The engineering problems of railroading have been solved in their broad lines. We will probably be able, as in the past, to keep on increasing axle loads and reducing ton-mile costs, but along lines indicated by carefully collected and thoroughly digested data of many years' work. This, as in the past, will be done by thoroughly trained and competent men knowing their business and eagerly looking for ways and means of getting better results.

With our highways problem we are now searching for the best solution. We have, generally speaking, inadequate and untrained or only partially trained forces. We have no accepted traffic unit and no generally recognized system of accounting. These must be supplied if we are to solve our problem as it should be solved.

HYDRATED LIME IN CEMENT AND CONCRETE.

Bulletin No. 10 of the National Lime Manufacturers' Association contains a report by Henry S. Spackman, of Philadelphia, on the effect of hydrated lime on strength and change in volume of cement mortars and concrete. The report is the result of tests on mortars and concretes with varying percentages of magnesium and calcium hydrate. The pieces were exposed under water and in air, outdoors, and alternately in water and in air. Examination was made to note the expansion of the pieces with variation in moisture content. The conclusions drawn by Mr. Spackman are as follows:

Variation in moisture content as well as change in temperature affect the volume of the test piece; when kept from contact with water other than the moisture in the air there is a marked tendency to shrinkage of the test piece, which tendency continues up to and beyond the six months' period; where the test piece is in constant or frequent contact with water, the general tendency is toward expansion in volume, and with the draining off of the excess gauging water there is a marked shrinkage in the 24-hour period followed in some cases by expansion at 48 hours and further shrinkage if test-piece specimens are out of contact with water and expansion if in contact with water; the addition of hydrated lime, while increasing somewhat the maximum expansion and contraction when the test pieces are constantly exposed either to water or dry air, markedly reduces the shrinkage due to the draining off of the surplus gauging water and also the extent of the movement when the test piece is alternately wet and dry.

Further tests for strength indicate that Portland-cement mortars and concrete, either with or without the addition of hydrated lime, develop the greatest strength when in continuous contact with water, and where allowed to harden in air out of contact with water there is a marked diminution of strength. Considered broadly, the addition or substitution of 10% of hydrated lime has no marked effect on the strength of the mortars, the test showing increase in strength at some periods and decreases in strength at others.

THE LAW OF STEAM POWER-HOUSE ECONOMY.*

By R. H. Parsons, M.Can.Soc.C.E., Assoc.M.Inst.C.E.

THERE are figures in abundance as to the performances of the component parts of a power-station, such as boilers, turbines, generators, etc., under test conditions, but nothing appears to have been published with respect to the efficiency with which the whole aggregation of machinery performs its functions. It is the purpose of this article to examine the performance of a power-plant, considered as an organic whole and to suggest a basis of comparison between different plants which has hitherto been lacking. The development of the method, moreover, will furnish an answer to many important problems of the central station engineer, as will be shown later.

The subject may be conveniently approached by an analogy. The efficiency of a steam-engine, under any conditions of working, depends upon a vast number of factors, mutually independent for the most part, such as cylinder condensation, radiation, friction of the various parts, leakage, etc. However carefully each of these items might have been investigated independently, their aggregate effect upon the economy of an engine would be an extremely difficult thing to forecast, and still more difficult would it be to deduce a law for the efficiency of the engine throughout its range of load, from the various rates of change of its multifarious sources of loss. By analogy we could hardly hope to determine the efficiency of a power-station at various loads from a consideration of the efficiencies of the different machines and apparatus which constitute its component parts.

The problem of the efficiency of the steam-engine was solved empirically by the late Mr. Peter Willans, who discovered that the total steam consumption per hour could be plotted as a straight line against the load on the engine. Thus, if the steam consumption at two different loads only were known, the consumption at any other load could be at once determined. This discovery placed in the hands of engineers an extraordinarily useful method of analyzing and tabulating the results of steam-engine trials. Experience proved the Willans law to have a remarkably wide range of application to prime movers, and for many years it has been utilized by manufacturers so far as it concerns their products.

By considering the analogy between the numerous sources of loss in a power-station and the almost equally great number of losses inherent in a steam-engine, it appears reasonable to suppose that there may be some rule corresponding to the Willans law which will correlate the efficiency of a power-station with the load upon it. Experiment proves this to be so, at any rate in the case of the particular power-station for the management of which the author is responsible, and no doubt a similar rule would apply generally.

In Fig. 1, above, the total steam consumption of the station per eight-hour shift is plotted against the gross electrical output of the station in the same period. The figures refer to the station performance during the month of September, 1914, and ninety records are plotted, covering a range of output varying from 4,500 to 24,300 kilowatt hours per shift. It might have been better to have taken the readings hourly instead of at eight-hour intervals, as this would have eliminated the effect of varying load-factors; but, on the other hand, the error

* From Engineering (London).

due to varying water-level in the boilers would be accentuated by the shorter intervals. The steam consumption during the shift is taken as being equal to the water pumped into the boilers, and the gross electrical output is the sum of the main-generator meter-readings.

By referring to Fig. 1, it will be seen that the mean of the observations is approximately a straight line, having the equation:—

$$S = 22\ K + 80{,}000,$$

where S is the total steam consumption per shift expressed in pounds, and K is the gross output per shift expressed in kilowatt-hours. It thus appears that there is a constant loss of steam, amounting to 80,000 lbs. per shift, and that there is in addition a consumption of about 22 lbs. of steam per kilowatt-hour.

Fig. 2 represents the steam-consumption curve of the station, expressed in pounds of steam per kilowatt-hour, the curve being deduced from the line shown in Fig. 1. The assumption has been made that the load-factor per shift was unity. From the equation it can be deduced that at an output of 80,000 kw.-hours per shift, which is the rated capacity of the station, the steam consumption would be 23 lbs. per kilowatt-hour. The consumption evidently tends to a limiting value of 22 lbs. per kilowatt-hour with an infinite load on the station.

The principle illustrated in Figs. 1 and 2 may be applied with equal instructiveness to the investigation of the quantity of coal consumed in the power-station. Fig. 3 shows the total coal consumption per eight-hour shift, plotted against the gross station output per corresponding shift, during the month of September, 1914; we see again that the total coal consumption follows a straight-line law, and may be expressed by the equation::—

$$C = 20{,}000 + 2.917\ K,$$

where C is the total coal consumption per shift expressed in pounds, and K is the gross electrical output per shift as registered by the generator meters. The diagram shows that 20,000 lbs. of coal are burned per shift to provide for the constant station losses, such as steam leakage, radiation, and general stand-by requirements. An additional 2.917 lbs. of coal per hour are needed for every kilowatt actually generated. With the station carrying its rated load of 80,000 kw. it may be deduced from the above equation that the coal consumption would amount to 253,360 lbs. per shift, or 3.16 lbs. per kilowatt-hour. In Fig. 4 is shown the coal consumption per kilowatt-hour corresponding to the line drawn in Fig. 3. The limiting value of the coal consumption is 2.917 per kilowatt-hour, which, of course, could only be obtained with an infinitely great load on the station.

From the two equations given above, namely—

$$S = 22\ K + 80{,}000,$$

and

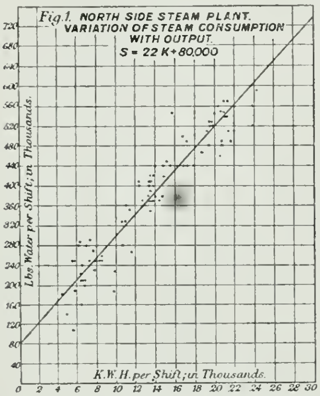
$$C = 2.917\ K + 20{,}000,$$

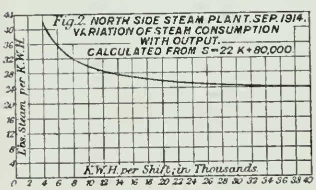
we may deduce a third equation, representing the variation of the amount of water evaporated per pound of coal, as the load on the boilers is increased. The equation is:—

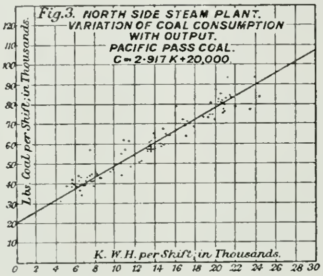
$$S = 7.54\ C - 70{,}820,$$

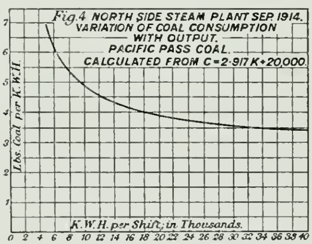
By equating it to zero, which represents the condition when no steam is being taken from the boilers, we get $C = 9{,}388$, showing that 9,388 lbs. of coal are required per shift to maintain the head of steam in face of radiation and other losses. This quantity may be compared with the amount of 20,000 lbs. per shift, which has already been found to be necessary to operate the station at no load. Thus about half the constant loss is attributable to the engines and half to the boilers. The equation further shows that the boiler-room losses are equal to the condensation of 70,820 lbs. of steam per shift, and that if they were absent we could evaporate 7.54 lbs. of water per pound of coal.

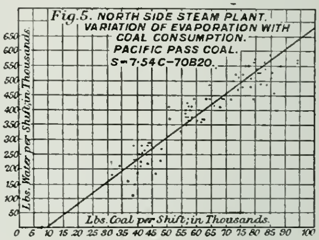
The last equation, correlating the total evaporation per shift with the total coal consumption per shift, could, of course, have been obtained graphically by plotting down the readings of the water-meters against those of the coal scales. In Fig. 5 this has been done, the line

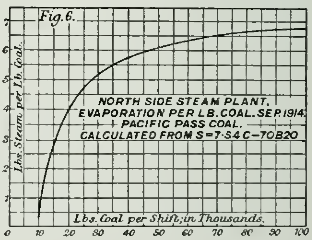












representing the mean of the observations being, however, drawn to agree with the calculation above. Nevertheless, it falls very fairly among the points. Fig. 6 shows the evaporation per pound of coal in accordance with this line.

In Figs. 1, 3, and 5, it may be objected that the variations among the observations do not allow a straight line to be drawn with any certainty, and hence a rather large amount of theory has been built up on a somewhat uncertain basis. This may be so, but the records are not put forward as being absolutely accurate. They are subject to corrections for water-level in boilers, coal on grates and in stokers, meter approximations, blow-off losses, etc., and they, of course, have a great dependence upon the economical operation of the plant, during the shift to which they refer. Nevertheless, they do undoubtedly appear to give evidence of certain laws of economy to which it is the object of this article to call attention.

The first question which will be asked by the practically-minded central-station engineer will be, "What use can be made of the results obtained from such an analysis of the operation of a plant?" One very important use can be made. The curves show at once the coal consumption or the steam consumption of the plant for any load which the station may have to carry. Hence the fuel cost for any additional load is readily obtained. For example, in the plant under consideration two problems were presented. One involved the question as to whether it would pay better to do the main waterworks pumping electrically or by steam-driven pumps. Steam had always to be maintained in the waterworks boilers, because the low-lift pumps were exclusively steam-driven; but the writer had the option of running either the motor-driven or the steam-driven pumps, as he thought fit. The combined labor costs of the two plants were unaffected by the decision. The waterworks load, when pumping was done electrically, was of a reasonably uniform nature, the load-factor per twenty-four hours being about 75 per cent. This load, as the equation corresponding to Fig. 3 shows us, can be carried on the steam plant at the cost for fuel of 2.917 lbs. of coal per kilowatt-hour. In an average month this would amount to 440 tons of coal, which figure can be directly compared with the extra coal burnt in the waterworks when the steam-driven pumps are operated. A definite solution of the problem can thus be obtained.

The other question related to the advisability of operating a large producer-gas engine, which normally runs in parallel with the main steam-power station. The gas-engine uses a low-grade lignite, costing about 0.16d. per kilowatt-hour. We see, as above, that the load could be transferred to the steam plant at an extra cost of coal of 2.917 lbs. per kilowatt-hour. But as the steam plant uses a more expensive fuel, the cost of 2.917 lbs. of steam coal amounts to about 0.26d. The fuel bill alone would therefore, be increased by 0.1d. per kilowatt-hour by making the change, but against this difference must be set the saving in labor, etc., which would result from shutting down the gas plant. The problem, like the former one, is, therefore, capable of an almost exact solution, which is only rendered possible by the foregoing analysis of the coal consumption of the main station.

The figures concerning the water and coal consumption of the power-station per shift, which have been taken as an illustration of the method, are actual working results obtained during the normal operation of the station. The month of September, for which they are given, was the first month for which it was possible to obtain them. They are put forward merely to illustrate a principle, and the writer is not concerned to defend them. Criticism should be directed not at the figures themselves, but at the use made of them. However, a brief explanation of certain points with regard to the station may not be out of place.

The power-station serves a non-manufacturing town of about 70,000 inhabitants, and furnishes alternating current for lighting and power, and direct current for street railway purposes. The plant comprises water-tube boilers with chain-grate stokers and superheaters, but without economizers. The generating machinery operated during the month of September consists of turbine-driven alternators for the lighting load and vertical high-speed engines and motor generators for the traction load. The condensing plant is partly steam-driven and partly motor-driven, and exciting current was furnished by a steam-driven exciter. In the diagrams above referred to the gross output of the main generators is given, this including the electrical energy used for auxiliary machinery and induced-draft fans in the station. The fuel used was a class of coal intermediate between lignite and bituminous coal, its average analysis being about as follows:

B. Th. U. per pound of dry coal	10,100
Moisture per cent.	7.3
Volatile matter per cent. (dry coal)....	26.5
Fixed carbon per cent. (dry coal)......	52.0
Ash per cent. (dry coal)..............	21.5

Although the writer trusts he has disarmed criticism of the operating results by the statements given above, it must not be assumed that the results are considered worthy of publication, except for the purpose of illustrating what appears to be the law of power-plant economy. The power-station is still rapidly approaching a higher degree of efficiency, as the following table of total generation costs will show:—

Period.	Total cost (including capital charges).
1st six months, 1912....	1.56d. per kw.-hour.
2nd " 1912....	1.37d. " "
1st " 1913....	1.12d. " "
2nd " 1913....	1.02d. " "
1st " 1914....	0.94d. " "

The costs per kilowatt-hour include the whole of the operation and maintenance charges of the plant in question, as well as the interest and sinking fund on the capitalization, which is particularly heavy.

In conclusion, it is suggested that a method of analysis has been indicated which will enable engineers to compare the working results of different power-stations by studying the respective equations of cost. It is also hoped that a means has been provided for forecasting with reasonable accuracy the cost of generating any extra load which may be offered to the station. The method might have been made more general, though less practical, by giving the results on a thermodynamic basis.

OTTAWA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

On Friday, December 4th, a goodly attendance of the Ottawa members was present at a luncheon. Mr. W. P. Macoun, Dominion horticulturist, gave a ten-minute address on "A New Country Club." Mr. A. St. Laurent, chairman of the Branch, presided.

SEWER WORK IN NARROW ALLEYS.

The problem of putting down a large sewer in a narrow alley, say, 16 ft., is one which frequently presents itself to the contractor. Methods vary, depending upon conditions governing disposal of excavation, etc., and upon contract requirements of various kinds, but the problem is sometimes made difficult by these conditions, if by nothing else.

In a letter to "The Contractor" some little time ago Mr. Ernest McCullough, consulting engineer, Chicago, describes a method that will be found of interest, differing more or less from other methods with which our readers may be more familiar. He assumes adverse conditions as regards dumping earth on paved streets at the end of the alley, breaking fences, etc., with operations confined entirely to the alley.

To begin, explains Mr. McCullough, the sewer trench will take up considerable space in the 16-foot alley. It is 48 inches in diameter, which means an over-all width of 6 feet to be excavated. The depth is 12 feet. The space along the sides is only 5 feet on each side of the trench. It is a shallow depth to work in by tunneling, but in this case I would tunnel. First, go along the line of the alley and brace all the fences inside the yards so dirt piled against the alley side will not destroy the fences. Where the fences have a fine appearance and the owner will resent keenly any defacement, place a lining of thin boards along the fence to a height of 5 feet.

Divide the alley into 12-foot lengths. On alternate lengths pile the material to be used in the construction of the sewer. Along the edge of the trench place boards about 1 foot high to keep the earth from falling back into the sewer. These boards can be tied by scantlings to posts driven along the fence line. Then we have on either side a 5-foot space ready to contain the excavated material. On the spaces holding material will be piled the sheeting to use for the sides of the trench. Set men at every space between the piles of material and let them get to the bottom as fast as possible. All the dirt will be thrown to the side except some direct from the tunnels under the material spaces, which may be left on a staging. The workmen will go straight down on the clear spaces, sheeting as they go so the heavy burden placed on the sides will not cause caving. They will begin to burrow under the material piles when they reach the depth which will cover the top of the proposed sewer and must place timbers under the material piles and line the tunnels to avoid caving and falls. When the burrowing begins the stagings appear; they should be not more than 5 feet long at first and even this length will leave an uncomfortably short throwing space at the ends. Such work is not cheap, although on a similar job our cost for 650 feet was done at 62 cents per cubic yard of excavation, which included back fill.

No time should be lost in starting the sewer when the cut is down to depth. Pumps may be required to take care of old sewers, etc., but such items are in addition to the excavating problem and must be solved when met. Rain is the greatest danger. On one job I put a canvas roof over the alley and sent the rain into the neighboring yards. Such work, of course, must be done only by permission of owners and damages must be repaired. When the sewer is in, side boards are removed after the sheeting is drawn and the earth shovelled in until the sewer is covered. The earth over the tunnel is broken down by picks so it falls on the sewer and takes care of uniform settlement. If possible no water should be used but the earth should be tamped dry. The tamping cost depends upon the intelligence of the man in charge. It should be merely enough so horses will not mire in the fill. This leaves a lot of earth still piled against the fences and this should remain until the whole block is sewered.

The next step is to run rollers over the trench and the loose earth should be plowed in until the alley is restored to grade, or a little above it. Horses' feet are the best possible tampers and the surface is finally settled by light rollers followed by heavy rollers. A light roller for such work is 3 tons and a heavy roller is between 7 and 10 tons. The surplus material, which should not be large in amount, is to be hauled away in wagons. Personally I prefer to place all the material over the sewer and raise the level of the alley for a time, later removing the surplus earth after settlement. In the case of a paved alley no plowing in can be done from the sides and the paving over the entire trench should be removed before the sewer goes in, over tunnel spaces and all, for the top of the tunnel should be broken down on the sewer. In a paved alley, of course, all the earth should be put in by shovel filling and tamping.

Usually not more than three sections will be opened at a time, for this permits of wagons going in and out from one end of the block. However, when plenty of men are available it is best to work along the entire length.

McGILL UNIVERSITY ATHLETIC FIELD.

Work started last August on the construction of an athletic field for McGill University, Montreal. It includes the construction of a reinforced concrete stadium with athletic field and running track, an out-door skating rink, a gymnasium and other accessory buildings, amounting in all to about $2,000,000. The contract has been awarded to L. A. Ott & Company, of Montreal. The excavation includes about 12 to 14 ft. of loose rock and earth amounting to 50,000 cu. yd. of shovel work and a considerable quantity of rock. A ⅞-yd. Bucyrus revolving shovel is being used on the work. Rock is being handled by hand into 1½-yd. dump cars which convey it to a crushing plant, where it is crushed and stored for use in the construction of the reinforced concrete grandstand. This structure is to be 400 ft. long with a seating capacity of 12,000.

The contract calls for completion in September, 1915. Work has closed down recently owing to weather conditions.

NEW C.P.R. STEAMER FOR PACIFIC COAST.

The first of two new passenger steamers that are being built for the Canadian Pacific Railway Company by Messrs. Denny Bros. & Company, was launched recently. The steamers will be used in the British Columbia service between Vancouver, Victoria and Seattle. The first, "Princess Margaret," measures 395 ft. in length and 54 ft. in breadth, with a 28-ft. 3-in. depth to promenade deck. It is driven by geared turbines, steam supplied by oil-fired water-tube boilers. Manoeuvring in port is effected by a large windlass forward and a steam capstan aft. Steering is effected by steam tiller acting on a balanced rudder and controlled by telemotor from the flying bridge. The vessel is to be fitted out with wireless telegraphy on the Marconi system and a special petrol-driven generating set is installed on the boat deck which is capable of working the wireless system as well as lighting the decks, even if there be no steam in the boilers.

Editorial

HIGHWAY LEGISLATION IN ONTARIO.

Ontario municipal corporations will welcome with avidity the recently issued publication of the provincial Department of Public Works, it being a compilation of Ontario highway laws, prepared by Mr. W. A. McLean, Commissioner of Highways. While members of municipal councils are largely taking advantage of the opportunity to equip themselves with this source of information in such convenient form, road and municipal engineers should not fail to add a copy to their own libraries for ready and reliable reference.

In the Province of Ontario the control of public roads was originally vested in the Crown, or Provincial Government, but responsibility has since been conveyed to city, town, village, township and county corporations, principally by the general Municipal Act of the Province. This Act defines the procedure whereby municipalities are created, and fixes their powers. Under it, townships are given control of all roads within their borders, except those that lie within towns, villages, or cities situated therein. In the latter case each urban municipality is responsible for the roads within its boundaries.

The more important provincial statistics relating to highways are given by Mr. McLean as follows:

Highway Section of the Municipal Act; Local Improvement Act; Statute Labor Act; Highway Improvement Act; Colonization Roads Act; Highway Travel Act; Motor Vehicles Act; Snow Roads Act; Tolls Exemption Act; Toll Roads Act; Snow Fences Act; Traction Engines Act, and Tree Planting Act. These are enumerated in the publication, with the exception of the Toll Roads and Tolls Exemption Acts, the reason for their omission being that there are now only 100 miles of toll roads in the province.

Mr. McLean draws special attention to the Local Improvement Act under which townships are now empowered to conduct road improvement in the same way as towns and cities, assessing the cost on the property benefited. Under this method the township council is authorized to pay a portion of the cost of the work, and payment of the balance levied on the property may be distributed over a term of years.

NEW WHARF ON RED RIVER.

The Department of Public Works will shortly commence the construction of one of three wharves recommended some time ago by the Winnipeg Harbor Commission. It will be known as the Rover Street wharf, and will be 400 ft. in length, 30 ft. in width and will cost in the neighborhood of $25,000. It is to be constructed of piles. A considerable amount of dredging is necessary, much of which has been done during the past season and which, when completed, will have reached an expenditure of about $90,000.

Further improvement on the river is being executed by the Department in the way of hydrographic surveys. Measurements have been made in the vicinity of St. Andrew's Locks, and others are under way at the present time between Selkirk and Lake Winnipeg. Still others are being carried out on the Winnipeg River.

During the year the Department of Public Works has performed improvements to the value of $400,000, of which about $75,000 has been done by contract.

WATERPROOFING OF MASONRY.

The following conclusions, prepared by the committee on masonry, of the American Railway Engineering Association, were adopted at the 1914 convention in Chicago:

(1) Watertight concrete may be obtained by proper design. Reinforcing the concrete against cracks due to expansion and contraction, using the proper proportion of cement and graded aggregates to secure the filling of voids and employing proper workmanship and close supervision.

(2) Membrane waterproofing, of either asphalt or pure coal-tar pitch in connection with felts and burlaps, with proper number of layers, good materials and workmanship and good working conditions, is recommended as good practice for waterproofing masonry, concrete and bridge floors.

(3) Permanent and direct drainage of bridge floors is essential to secure good results in waterproofing.

(4) Integral methods of waterproofing concrete have given some good results. Special care is required to properly proportion the concrete, mix thoroughly and deposit properly so as to have the void-filling compounds do the required duty; if this is neglected, the value of the compounds is lost and their waterproofing effect destroyed. Careful tests should be made to ascertain the proper proportions and effectiveness of such compounds.

Integral compounds should be used with caution, ascertaining their chemical action on the concrete as well as their effect on its strength. As a general rule, integral compounds are not recommended, since the same results as to watertightness can be obtained by adding a small percentage of cement and properly grading the aggregate.

(5) Surface coating, such as cement mortar, asphalt or bituminous mastic, if properly applied to masonry reinforced against cracks produced by settlement, expansion and contraction, may be successfully used for waterproofing arches, abutments, retaining walls, reservoirs, and similar structures; for important work under high pressure of water these cannot be recommended for all conditions.

(6) Surface brush coatings, such as oil paints, and varnishes, are not considered reliable or lasting for waterproofing of masonry.

SURGE TANK PROBLEMS.

Of the series of articles entitled "Surge Tank Problems" by Prof. Franz Prasil, of the Eidgenössische Teknische Hochschule, Zurich, Switzerland, published some few months ago in *The Canadian Engineer*, and being an authorized translation by Messrs. E. R. Weinmann and D. R. Cooper, hydraulic engineers, New York City, the "Engineering Record" has this to say:

"The treatise here offered is the best and clearest on surge-tank phenomena so far published in the English language."

BOW RIVER HYDRO-ELECTRIC PLANTS.

An article in *The Canadian Engineer* for December 3rd, 1914, dealt with stream flow investigations, relating specially to those of Mr. M. C. Hendry, of the Water Power Branch, Department of the Interior, based upon his studies of the Bow River above Calgary. His recent report describes, in brief, the existing developments on the river, and outlines the possible developments which other stretches of it and its tributaries possess.

The following is a brief résumé of the characteristics of the existing plants, and is presented in a complementary way to the information which has already appeared in these columns relative to the two largest developments, *viz.*, at Horseshoe Falls and Kananaskis Falls.

Eau Claire Plant.—The first hydro-electric development on the Bow River, in the section from Calgary west, is that of the Eau Claire Lumber Co., situated within the city limits. The development makes use of the natural fall in the river, by means of a diverting dam (pile and timber construction) and a canal, and the head developed is in the neighborhood of 12 feet. The diverting dam is situated just above the bridge crossing the Bow River at 9th St. W., and the intake and canal are on the south side, the canal following the south bank for about ½ mile. Advantage is taken of small islands or gravel bars, and these, together with timber pile structure, form the stream side of the canal. At the lower end, an island forms the north side of the canal or forebay, the original channel between it and the mainland forming the tail-race. Leffel wheels, set in an open timber wheel case, spanning the channel, are geared to two jack shafts, bolted to two generators. The installation is for 600 h.p.

The head developed is about 12 feet, the total flow of the river at low water being utilized. The company has the right to the total low flow of the river at that point, and an amount equal to the low flow at high and normal stages of the river. This plant supplies power for lighting throughout the city of Calgary, having a franchise for the distribution of power. The water-power is assisted by steam-generated power, and in consequence the service is liable to very few interruptions, but it is understood that during the winter season the operation of the water-power plant is interrupted for considerable periods, owing to ice troubles.

Lake Louise Power Plant.—An interesting power development in the Bow basin is that operated by the Canadian Pacific Railway in connection with the hotel at Lake Louise, near Laggan. This plant supplies light to the hotel at the lake, the station and surrounding houses and buildings. During the summer of 1912, the plant was enlarged and changed, and the output of the station increased.

The original plant was operated under a head of 45 feet, obtained by means of a concrete dam 75 feet long built across the bed of Louise Creek, about a quarter of a mile below the outlet of the lake; from the intake a 16-inch wooden stave pressure pipe led to the power house situated further down the creek, the head obtained being secured by the natural fall in the creek. A 35-kw. machine belted to the turbine, together with a switchboard, formed the station equipment.

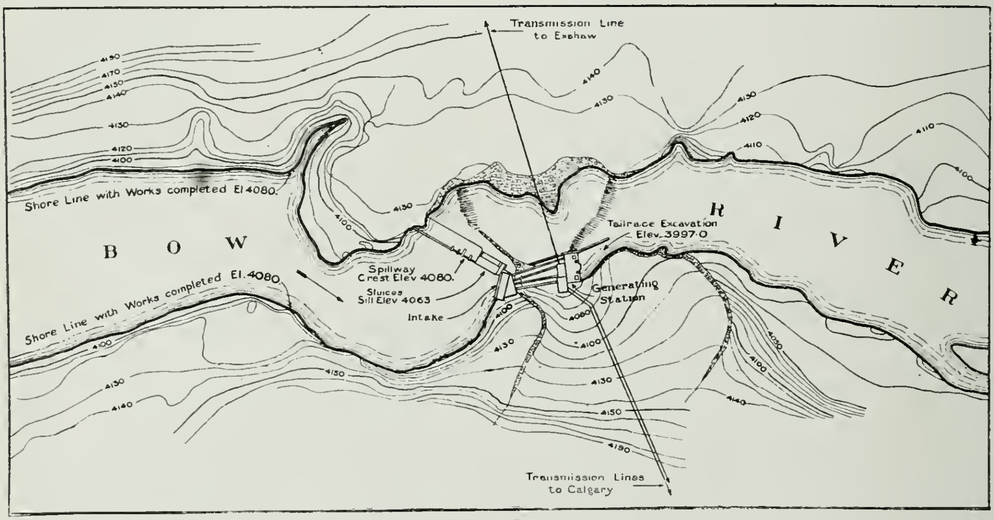


Fig. 1.—General Layout of the Horseshoe Falls Development.

The new installation, rendered necessary by the increased hotel accommodation, involves a concrete dam placed at the outlet of the lake, and forming part of the intake. The structure is in the nature of a bridge having the spill sections situated between the piers, and is so built that the former high, low and normal levels of the lake will still obtain. The pipe line which conveys the water to the plant is a wood stave pipe 20 inches in diameter and approximately 2,800 feet long. It is laid on the east side of the creek for the greater part of the distance, and the gross head developed is approximately 140 feet. The pipe line leads to a 24-inch S. Morgan Smith wheel which runs at 600 r.p.m. The wheel is rated at 100 h.p., and is belted to a 75-kw., 3-phase generator which operates at 1,200 r.p.m. and has an exciter mounted on the shaft. The current is transmitted at 2,500 volts and stepped down to 125 volts for lighting and other uses.

The development is interesting from the standpoint of utilization of the flow, which is very limited at all seasons, during the high-water period, and illustrates the value of small hydro-electric plants to the tourist centres.

Horseshoe Falls Plant.—The largest power development on the Bow River, at present completed, is that of the Calgary Power Company. This plant is located at Horseshoe Falls, about 50 miles west of Calgary, and here one of the very few concentrated falls to be found upon the Bow, is utilized.

At this point the Bow River in its natural state flows through a deep gorge, the walls and bed of which are formed of a shale banded with sandstone. At the point of development a rock outcropping, which is in the nature of an anticlinal dip, occurs. This has been considerably eroded, and forms a drop in the bed of the river of approximately 25 feet. A solid concrete dam has been built across the gorge upon the lip of this outcrop, and this, with the natural fall, produces a head of 70 feet.

The dam is of solid spillway type, with an inspection and drainage tunnel. In addition to the spillway there are 8 sluiceways, provided to take care of flood discharges; four being simply stoplog openings and four being supplied with sluice-gates. The former are 7 ft. by 22 ft., the stoplogs being handled by means of hand winches. The other four are controlled by sluice-gates 19 ft. by 14 ft. of a modified "Stoney" type, operated hydraulically. The spillway section is 140 feet long and, together with the sluices, is sufficient to discharge a flood of 40,000 c.f.s. The inspection tunnel, access to which is gained by means of a well situated midway between the stoplog openings, extends under the spillway section into the rock at the west abutment of the dam. The intake structure is distinct from the dam and occupies a position adjacent to it, approximately parallel to the stream flow. The water, which is admitted through racks and concrete chambers to the 4 penstocks, is controlled by means of stoplogs and butterfly valves placed in the inlet chambers.

The penstock arrangement was described in *The Canadian Engineer* for August 6th, 1914, page 266, to which description the reader is referred. The power house, the main part of which measures 118 ft. by 56 ft., is situated in the gorge below the dam. It is of steel, concrete and brick construction, and houses the turbines, generators, exciters, etc. At the back of the power house, and partly over the penstocks, the switch and transformer rooms are built. The tail-race is protected from back water in time of flood by means of a wing wall, which separates the tail-race from the river for some distance below the power house.

The complete turbine installation consists of four turbines of the horizontal double-runner type in steel wheel cases, and two exciter turbines of the single-runner type, the latter being of 330 h.p. capacity each. Two of the main units are of 3,750 h.p. capacity and, with the governors, were supplied by the Jens Orten-Boving Co. They are of Swedish manufacture, as are also those of the exciter sets. The other two main units are of 6,000 h.p. each, built by Wellman Seaver Morgan Co., of Cleveland, Ohio, and are controlled by Lombard governors. The smaller units are directly connected to two generators, of 2,500 k.v.a. capacity, being 3-phase, 60 cycles, 300 r.p.m. machines and operating at 12,000 volts. The other two units are direct-connected to generators of 4,000 k.v.a. capacity, operated at 12,000 volts, 3-phase and 60 cycles. The generators of the exciter sets are 175 kw., 125-volt, and 700 r.p.m. machines. The generators were built and supplied by the Canadian General Electric Company.

The transformer room contains two 3,000 k.v.a., 12,000 to 55,000-volt, oil-insulated, water-cooled, 3-phase transformers, and two more of the same capacity will be installed very shortly.

The company has three transmission lines in operation, one extending to Exshaw, a distance of 8 miles, and the others forming a duplicate line to Calgary. The Exshaw line supplies power to the Canada Cement Co.'s plant at that place. It is a double-circuit, 3-phase, 12,000-volt line, strung on wooden poles, the conductors being of six 00 aluminum stranded cable. In connection with the line there is a telephone line strung upon the same poles, and also a ground wire. The transformer station at Exshaw contains four 700 k.v.a., 12,000-600-volt, oil-insulated, water-cooled transformers, with lightning arrestors and switching apparatus complete. The switch apparatus in this station was installed by the Canadian General Electric Co., and the transformers by the General Electric Co. of Sweden.

The transmission line to Calgary is in duplicate; each is a single-circuit, 3-phase, 55,000-volt line, the conductors being No. 0 aluminum, with telephone line and ground wire carried on 40-ft. wooden poles. The lines are

Fig. 2.—Horseshoe Falls Plant of the Calgary Power Co.

parallel to one another for the first 10½ miles from the power house, and follow the Canadian Pacific Railway. These lines handle the power output of both the plant at Horseshoe Falls and that at Kananaskis Falls, now being built.

The design and construction of the plant was carried out by the engineering firm of Smith, Kerry & Chace. The dam presented some interesting problems which required considerable thought and care in solving.

In order that the site of the foundation might be unwatered, and the discharge provided for during construction, two unwatering tunnels were driven on the intake side of the river, from the under side of the lip of the falls up to the upper level, and at such an elevation that only a low cofferdam was necessary to keep the water out of the foundation of the dam. The rock outcrop which forms the fall, and upon which the dam was constructed, dips across the river at a considerable angle, and upon unwatering and exploration of the lower part (the section near the north bank) it was found that the material which is illustrated in the section shown on the plan of the development was not of a satisfactory nature for foundation purposes. An examination proved that no better material underlay it, and this material necessitated special treatment. While the section containing the sluiceways was being built, Mr. John R. Freeman was called in by the company to advise in the matter. His report of October 10, 1910, accompanied by plans showing layout and proposed changes, was acted upon, and the plans

of the plant as built, included here, embody the recommendations made.

The following precautions were taken, based upon the report:—

1. The hard sandstone ledge, upon which the dam was to have been built, dipped at such a considerable angle that the cost of carrying the foundations down to this rock throughout the length of the dam, would have been excessive. The northern part of the dam was therefore built upon the shaly rock, overlying the hard sandstone, which it was considered would afford a safe foundation.

In order to obviate any leakage that might develop through the underlying seams, 3-inch holes were drilled through the rock, about 2 ft. in front of the face of the dam, 10 ft. apart, and to a depth of about 40 ft., a casing was then placed in the upper part of the hole, and a thin cement grout forced into the holes under a pressure varying between 60 and 80 lb. per sq. in. until they refused to hold any more. By this means the grout was forced into seams in the rock, cross-cut by the holes, and for a considerable distance from the holes. By first filling alternate holes and later filling the remainder, it was expected that all the seams would be completely filled for some distance from the line of holes.

2. The possibility of leakage around the north end of the dam was met by excavating a considerable distance into the cliff, for the total height of the dam. The cliff consists of a soft shale, liable to disintegration on exposure to air, but as the excavations were completely filled with concrete, any water leaking through the seams in the shale would be forced to travel a considerable distance, and the quantity would be greatly reduced by friction, and as the seams are liable to silting, the leakage would be very nearly eliminated.

3. The inspection tunnel also serves the purpose of a drainage tunnel. Drainage holes, about 16 in. square, and placed 16 ft. 8 in. apart, extend from the springing line of the arch of the tunnel upward through the body of the dam, so that any leaks that may develop through cracks will be intercepted and directed into the drainage tunnel. Other holes, 3 in. in diam., and about 12 ft. 6 in. apart, have been drilled down through the base of the dam into the underlying rock for depths of from 10 ft. to 18 ft. These are cased at their upper end, in order that the quantity of any water leaking through them and also the upward pressure may be measured.

4. The tunnel has been extended into the rock forming the north abutment of the dam for a distance of some 30 ft., so that most of the leakage around the end, if there is any, will be intercepted by the tunnel. This expectation has been realized by the stopping of leakage going on before the tunnel was extended. The tunnel itself is drained through an opening in the downstream side of the dam.

5. The protection of the foundation of the dam at the downstream side has required careful consideration. In order that erosion due to the water coming over the spillway section might be eliminated, Mr. Freeman recommended that the apron of the dam be extended downstream about 40 ft., heavily reinforced and anchored to the rock, and that baffle piers be built on the apron to reduce the velocity of the water and thereby prevent any possible erosion. Other recommendations were made, one being the building of a baffle wall on the crest of the old falls at the south end of the dam, and the facing of the cliff below to prevent undermining.

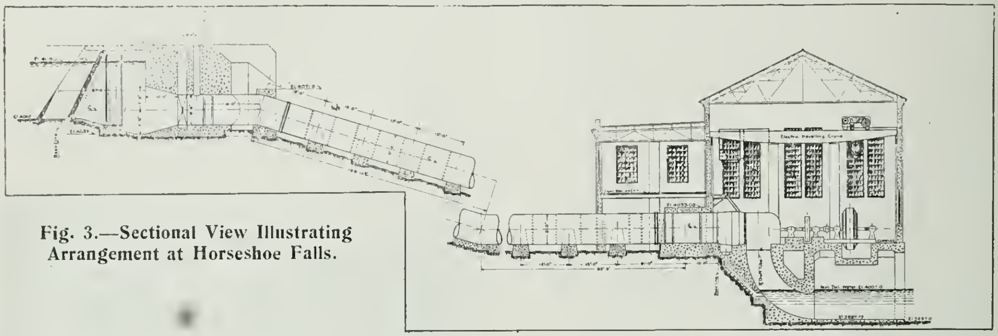


Fig. 3.—Sectional View Illustrating Arrangement at Horseshoe Falls.

The Kananaskis Falls Plant.—This development, the most recent on the Bow River, was described in considerable detail in our issue of August 6th, 1914.

SOUTH AFRICAN RAILWAYS.

The open mileage of Government-owned lines in South Africa at the end of 1913, was 8,281 miles, of these 7,807 miles being 3 ft. 6 in. gauge and 474 miles of 2 ft. gauge, the total increase during the 12 months being 433 miles. The mileage of new lines opened for traffic totalled 385 miles divided between the four provinces as follows:—Cape, 102 miles; Orange Free State, 56 miles; Transvaal, 105 miles; and Natal, 64 miles.

The position of the provinces on December 31, 1913, as compared with the end of the previous two years, was as follows:—

	1913.	1912.	1911.
Cape	3,638	3,492	3,397
Free State	1,162	1,106	1,070
Transvaal	2,362	2,197	2,020
Natal	1,116	1,052	1,052

The figures given above represent Government-owned lines only, with the exception of 50 miles leased from the Natal-Zululand Railway Company. The administration works the section from Vryburg to Bulawayo (597 miles) owned by the Rhodesian Railways, and also 56 miles privately owned within the Union.

Parliament authorized the construction of 14 new lines, but at the end of 1913 their construction had not been entered upon. The total mileage of these authorized lines was 794½ miles, the provincial allocation being: Cape, 306¼ miles; Transvaal, 191 miles; Orange Free State, 166½ miles; and Natal, 130¾ miles.

Coast to Coast

Chatham, Ont.—The city expects to have Hydro-Electric lighting before the middle of January.

Victoria, B.C.—A municipal paving plant, for which contracts were let last spring, will be constructed and made ready for operation during the winter.

St. John, N.B.—The new docks at Carleton were formally opened last week, and the completed structure turned over to the Department of Public Works by the Maritime Dredging and Construction Co.

Victoria, B.C.—The new Canadian Northern Pacific wharf to be constructed at Patricia Bay will, according to an announcement by Mr. D. O. Lewis, divisional engineer of the C.N.P., be commenced immediately, the contract having been awarded to Mr. J. Doe.

Kamloops, B.C.—The Hydro-Electric power plant on the Barriere River (described in *The Canadian Engineer* for November 5th, 1914), has been put into operation. The installation provides for a maximum development of 20,000 h.p. At the present time about 6,000 h.p. is being developed.

Brockville, Ont.—The Hydro-Electric Power Commission of Ontario will shortly construct a transformer station, 20 x 39 ft., at an approximate cost of $4,000, to be used in connection with the new power line now under construction from Prescott. This line will be completed in the spring. It will carry current at 26,400 volts, which will be stepped down to 2,200 volts for use in Brockville.

Welland, Ont.—The new factory of the Tuttle-Bailey Co. of Canada, Limited, has been completed. It is of reinforced concrete and steel, 100 x 200 feet in dimensions, and has been erected at an expenditure of about $60,000. The company will manufacture steel registers. It will employ about 50 men. Peter S. Gordon is local manager. The company has a branch at Winnipeg, Man.

Sydney, N.S.—By the end of the year the Intercolonial will have completed 105 new steel bridges, to take the place of the light bridges so numerous along its line. The railway is making wholesale preparations for the handling of heavier traffic, and the steel structures now being erected are designed to meet the requirements for many years to come. With their construction going on, the purchase of more powerful locomotives and for larger and better transportation equipment are being looked after.

Toronto, Ont.—The Commissioner of Works has recommended to the city council the construction of a highway running north and south through Mount Pleasant Cemetery, to afford a thoroughfare between North Toronto and East Rosedale. The estimated expenditure upon this much-needed improvement is $275,000. Another similar recommendation has to do with a road to run east and west across Prospect Cemetery to create a thoroughfare between Dufferin St., to cost between $25,000 and $30,000.

Vancouver, B.C.—The bulkhead belonging to the C.N.P. terminal scheme in False Creek is nearing completion, and reclamation work will be resumed at an early date. Over 3¾ million cubic yards will be required to build up the area under improvement. Of this amount over 1,000,000 cubic yards have already been deposited by the Pacific Dredging Co. This company is also dredging out the deep-water channel in connection with the harbor improvement scheme of the Department of Public Works.

Toronto, Ont.—As announced elsewhere in this issue, thhe city council has accepted the tender of Messrs. Quinlan and Robinson, of Montreal, for the construction of the Don Section of the Bloor Street Viaduct, according to plans and specifications prepared by the Department of Works of this city, under the direction of Mr. R. C. Harris, Commissioner of Works. These specifications cover a steel structure with concrete abutments and piers. The plans were described in *The Canadian Engineer* for October 29th, 1914.

Winnipeg, Man.—It has been announced that the construction of the aqueduct for the Greater Winnipeg Water District will be commenced in March. The close of the construction season finds the right-of-way located and cleared; a 90-mile railway constructed through country, much of which consisted of muskeg and timber; partial completion of the dyke across Indian Bay, 1½ miles in length; completion of preliminary channel connecting Indian Bay with Snowshoe Bay; a telephone line, permanently constructed for the full length of the system; ballast-pits located and open, and a large amount of fencing done.

Cobalt, Ont.—The Cobalt Reduction Co. has commenced the construction of an addition to their present mill. This addition will be a cyanide plant, to have a daily capacity of between 125 and 150 tons. It is to be completed and ready for operation next March. This plant will treat by the cyanide process the slimes produced by crushing operations in the mill. The building will be 193 ft. x 70 ft., with an additional wing, 80 ft. x 70 ft. The foundations are to be of concrete, and the superstructure of steel and fireproof material. The machinery to be installed will include the usual classifiers, settlers, agitators, and vacuum filters necessary in the process.

PERSONAL

P. B. MIGNAULT, K.C., has been chosen to succeed Hon. T. C. Casgrain as member of the Canadian section of the International Joint Commission.

CHARLES L. WISNER has been appointed to succeed Mr. J. H. Housser, deceased, on the board of directors of the Massey-Harris Company.

A. E. STEVENS, of Vancouver, has been appointed general superintendent in Alberta of the Canadian Pacific Railway, succeeding Mr. D. C. Coleman, with headquarters at Calgary.

A. PRICE, assistant general manager, Canadian Pacific Railway, read a paper at a meeting of the Canadian Railway Club last week in Montreal. His subject was "Some Maximums and Minimums in Train Operation."

SAMUEL HALE, manager of the Algoma Steel Corporation, is about to retire, according to a press report. Mr. J. F. Taylor, president of the company, will take charge of the works and of the operation of the plant.

J. J. FERRIS, superintendent of oil service, Canadian Pacific Railway, delivered an illustrated address on "Fuel Oil and its Application" before the regular meeting of the Vancouver Branch of the Canadian Society of Civil Engineers on December 3rd.

OBITUARY.

The death occurred in Montreal last week of Mr. James A. Baylis, chief engineer of the Bell Telephone Co. of Canada. Mr. Baylis was a graduate of Worcester Polytechnic Institute, and has been in the employ of the Bell Telephone Co. since 1890. Mr. Baylis was a member of the American Institute of Electrical Engineers.

The death occurred in Chicago last week of Mr. R. M. Greene, a structural engineer, of Winnipeg, and a former instructor at the University of Manitoba.

UNIVERSITY OF TORONTO ENGINEERING SOCIETY.

On December 9th the members of the University of Toronto Engineering Society assembled to pay tribute at a memorial meeting to the late Dr. John Galbraith, dean of the Faculty of Applied Science and Engineering. The meeting was addressed by several of the older graduates, including Mr. G. H. Duggan, vice-president and chief engineer of the Dominion Bridge Co., and a graduate of 1883, and Dr. T. Kennard Thomson, consulting engineer, New York, and a graduate of '86. Mr. E. D. Gray, president of the Society, was in the chair.

The speakers referred to their early associations with Dean Galbraith and to the remarkable development of the Institution, as viewed by them from a distance, since graduation. In his remarks, Dr. Thomson reviewed briefly the engineering career of the departed man, touching upon his exceptional character, marvellous foresight and preponderant spirit. The late educationist's policy was reviewed and eulogized as one which developed in the old graduates as time went on the feeling that the course of instruction which they had received from him was of far greater value than could be obtained from any course in the best modern University.

On the following day another meeting of the Society was addressed by Dr. Thomson on the foundations for bridges and buildings, especially as regards pneumatic caisson work.

Compressed-air caissons were first used on this continent in North Carolina, in 1852 for bridges, and in 1893 in New York City for buildings. Now many bridges and buildings are supported by foundations obtained by this method.

Photos were shown of the beautiful stone arch bridge over the Connecticut River, at Hartford, and accidents were described which happened in the Susquehanna, Missouri and other rivers. Many New York skyscrapers were described, especially those whose cellars are 16 to 32 feet below the level of the surrounding ground-water. No difficulty is experienced in keeping them dry, as described.

The difficulties of pile-driving were also shown by photos of many very badly driven piles. The underpinning or placing of new foundations under old buildings as high as 18 stories, without allowing the building to settle, was also explained in detail.

A description was given of the removal of a 17-story building on penumatic foundations, which was removed after 14 years' service from the corner of Wall and Nassau Streets to make place for the 39-story Bankers Trust Building. In this connection it was noted that where the steel columns were in contact with concrete no rusting had commenced, but where there was an air space between the steel and concrete, then rusting had made considerable progress.

AMERICAN CONCRETE INSTITUTE.

The eleventh annual convention of the Institute is to be held in Chicago, February 9th to 12th, 1915. The following is a summary of the programme:—

Concrete Roads, Sidewalks and Bridges.—Papers and discussions relating to the status of concrete road construction will be presented, and special attention given to costs, repairs and maintenance.

Concrete and Reinforced Concrete Tests and Design.—Discussion of the column tests made by the Institute at Pittsburgh, tests of buildings, and other matters of current special interest.

Concrete in Art and Architecture.—Discussion of architectural design in concrete, dimension and art concrete stone, treatment of surfaces, etc.

Plant Management and Costs.—Devoted to concreting plants, covering plant management and costs, the design and cost of wood and metal forms, and the methods of placing, proportioning and selection of concrete materials.

EDMONTON BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The next regular meeting of the Edmonton Branch will be held on January 6th, and will be addressed by Mr. A. J. Latornell, city engineer, Edmonton. His subject will be a description of the trunk sewer system of Edmonton.

An interesting syllabus of papers for the season has been prepared. On November 4th Mr. R. H. Parsons read a paper entitled "The Prevention of Electrolysis Due to Street Railway Tracks." On December 2nd Mr. J. Chalmers read a paper, "Depreciation as Applied to Public Utilities." Future meetings include a paper on military engineering, to be given in February by Mr. D. Donaldson. Messrs. J. Brodie and J. A. Allan will take up the subject, "Natural Gas in Alberta, with Geology Incident Thereto," at the March meeting. The April paper will be "Electric Railway Operation and Management," by Mr. J. H. Larmouth. The May meeting will be devoted to general business of the Branch. The members meet fortnightly, each alternate meeting being of a more or less informal nature, with a dinner as part of the programme. Commissioner J. Chalmers is chairman of the papers committee.

CLAY WORKERS' CONVENTION.

The annual convention of the Canadian National Clay Products Association will be held in Toronto, January 26th-29th, 1915.

COMING MEETINGS.

AMERICAN FORESTRY ASSOCIATION. — Annual meeting to be held in the Woolworth Building, New York City, January 11th, 1915. Secretary, P. S. Ridsdale, Washington, D.C.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.—Annual Convention to be held at the King Edward Hotel in Toronto, January 26, 27, and 28, 1915. Secretary, G. C. Keith, 32 Colborne Street, Toronto.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—Twenty-ninth annual meeting, to be held in Montreal, January 26th, 27th and 28th, 1915. Secretary, Prof. C. H. McLeod, 176 Mansfield Street, Montreal, Que.

EIGHTH CHICAGO CEMENT SHOW.—To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.

AMERICAN WATERWORKS ASSOCIATION. — The 35th annual convention, to be held in Cincinnati, Ohio, May 10th to 14th, 1915. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—Annual meeting to be held at the Iowa State College, Ames, Iowa, June 22nd to 25th, 1915. Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Volume 27. Toronto, December 24 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

METHODS OF TREATMENT OF SEWAGE SLUDGE

PROF. P. GILLESPIE, C.E., REVIEWS THE METHODS IN VOGUE IN AMERICA AND EUROPE — ABSTRACTS FROM A VALUABLE PAPER TO THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

A VALUABLE addition to literature on sludge disposal is contained in the paper presented on December 17th to the Canadian Society of Civil Engineers by Prof. P. Gillespie, of the University of Toronto. The formation of sludge is described, the paper confirming the frequently expressed generalization that American sewage contains up to one part per thousand of solid matter. It is with the treatment of this solid matter, partly in suspension, partly in solution, and partly in colloidal state, that Prof. Gillespie's paper deals, this treatment being such that the sludge ceases to possess properties in virtue of which it may prove a nuisance to the community or a menace to its health. The speaker calls attention to the fact that while the noted fifth report of the Royal Commission on Sewage Disposal devotes much space to detailed descriptions of various methods of sludge treatment, including conversion into fertilizer, depositing at sea, pressing, burning and trenching, and while in its recommendations every other matter is referred to, no specific recommendation is made with respect to the disposal of sludge.

The values of the fertilizing constituents (potash, nitrogen, phosphates, etc.) are dealt with, and the methods employed in this field outlined. The effect of decomposition on the fertilizing value of sludge is emphasized, it being due to dimunition of nitrogen content and of phospherous, a more porous non-fibrous constitution of nitrogenous material and a finely divided and more uniformly distributed condition of contained grease.

The paper divides methods of sludge treatment into (1) those which deal with crude sludge and (2) those which deal with decomposed sludge, owing to the radical differences and the methods of disposal best suited to each. These differences are described and explained.

The various methods of treating crude sludge are described. Disposal at sea, for cities fortunately located, is a method in quite general use, satisfactory and reasonably cheap. This method is practised in Providence, R.I.; Boston, Mass.; London, Salford, Manchester, Dublin, Belfast and Glasgow. The latter city reports a cost for this work equal to 3.1d. per long ton of sludge handled, including .9d. per ton for land charges. In London the cost is about 7 cents per ton of sludge, not including the cost of precipitation and pumping into barges.

The following costs per ton of 2,000 pounds of dry matter are reported: London, $1.03; Glasgow, 87 cents; Manchester, $1.26; Salford, 90 cents, and Dublin, 91 cents. Precaution must be taken to avoid pollution of shellfish layings and the deposition of solid matter where it can possibly be carried to any foreshore.

Methods of land disposal include air drying, trenching, and lagooning, none of which have been attended with anything better than partial success. The next method considered is that of treatment by use of the centrifugal machine, whose operation is described in detail. The process of pressing, whereby handling is facilitated, odor diminished, and capacity for putrefaction lessened, is explained. The sludge is here subjected, between plates, to a pressure of about 75 pounds per square inch. Its volume is about 1/5, after the treatment, and the water content is reduced 50 per cent. This method is in use in Hamilton, Ont.; Worcester, Mass.; Providence, R.I., and Bradford, England.

The writer claims the treatment of rotted sludge by filtering it on properly constructed beds, as being the only satisfactory method. The procedure in Great Britain (at Birmingham) and on the European continent (in the Emscher Valley) is described, it being strikingly similar in both cases, the main difference lying in the manner of sludge preparation.

At Birmingham plain sedimentation is employed. The sewage after passing through a grit chamber and being roughly screened is passed into sedimentation tanks, where the sludge is deposited. This sludge is removed from each tank weekly in summer, less frequently at other seasons, and deposited in one or more of a series of twenty tanks where septic action and digestion take place. Following this, the sludge is pumped to the drying beds which are each 150 feet square in area, consist of 6 inches of clinker and ashes, and are underdrained with 4-inch tiles laid in herring-bone fashion toward a main leader, which in turn takes the drainage to the well whence it is pumped to the filtering beds. Each bed gets two fillings per year

In the Emscher Valley the sludge is rotted in the lower compartment of two-story tanks, the upper compartment being the sedimentation chamber. It is periodically removed and dried on prepared beds, similar in construction to those at Birmingham. The drying period is considerably longer.

The writer deals to some length with plain sedimentation, the term denoting the subsiding of solids heavier than water, which takes place when conditions are favorable. The influences affecting it in the treatment of sewage are the velocity of flow, time of retention, specific gravity and size of settling solids. The observations of

Beck and Schwarz, Hanover, in 1899, were cited, where it was found that with a velocity between .014 and .027 feet per second, 55.7 per cent. of the suspended solids were settled out in 2¼ hours. When the period of retention was increased by 50%, this percentage of sedimented solids became 61.5. Steuernagel reported that complete quiesence for 12 hours removed 84%. Of American data the Columbia tests are noted.

The writer calls attention to the criticism which is attendant upon the method of expressing the sedimented solids as a percentage of the total solids in suspension, the latter having been determined by careful filtration of samples, in estimating the efficiency of sedimentation processes.

"Without doubt it leads to confusion in a comparison of results since it takes no account of the fact that there are always some solids which refuse to settle because their specific gravity is practically that of the water containing them or else through fine division they are in a state of semi-solution. A sedimentation plant has no more concern with non-settling solids than it has with matters in solution."

The paper goes on to describe the first attempt, by W. J. Dibden, London, at giving separated sludge a treatment independent of that given to the liquid sewage. Mr. H. W. Clark's observations (1899-90) were outlined, and followed by a full description of the Travis or Hampton hydrolytic tank, patented and put into service in 1903 and now in operation on a commercial scale at Hampton, Norwich and Luton, England. The circumstances surrounding the first German modification of this tank are also described in an interesting way.

Prof. Gillespie then traces the development of the septic tank, outlining the early experiments, particularly those of Doctors Guth and Spillner. The work of the Emschergenossenschaft was described,* and the typical Emscher plant outlined in detail. Each part, *viz.*, storm overflow weirs, screening chamber, detrieus tank or grit chamber, Imhoff sedimentation tank, and sludge beds, is taken up, carefully studied, and illustrated. An interesting parallel is drawn between what is commonly called the "British" and "German" methods, the former, as already described, embodying sludge digestion in separate tanks, and the latter, sludge decomposition in 2-story tanks. Both processes are termed satisfactory; both produce inoffensive and quick-drying sludge. Commenting upon them, the writer states that his observations have led him to believe that sludge which has been thoroughly digested in separate tanks does not differ materially as to character or quantity from that which has undergone digestion in Imhoff tanks, or indeed in ordinary septic tanks. "There are, however, certain objections to the method of decomposition in separate tanks which are significant. In the first place, where separate digestion tanks are employed, the overflowing excess liquid is very offensive and the escaping gases are likely to be very noxious also. Again, for the maintenance of bacterial life, it seems obvious that the food supply (fresh sludge) should enter the chamber continuously, and that the rotted sludge should be withdrawn as nearly as may be in the same way. The separate tank does not usually provide for this, while the two-story tank does. The proper environment seems to require time for its development, and after this environment is once created, it seems like taking a great risk to renew the entire contents of a tank at one operation instead of permitting the supply of food to come in gradually. Experience, moreover, has shown that the time required for complete digestion is likely to be longer in the separate tanks than in those with two stories. The body of water overlying the sludge in the decomposing room of two-story tanks, performs a function which it is not possible to duplicate in the ordinary tank for separate sludge digestion. This body of water is a medium in which the old sludge and the new, through the ebullition caused by the escaping gases, have an opportunity of becoming mixed, and one in which, as explained later, its soluble constituents may often exert an important influence in preventing acid decomposition.

"Fresh sludge separates from its water only with the greatest difficulty, the reason being the attraction of its contained colloid constituents for water. Structurally, the mass is supposed to be divided into cells by a network of amorphous membranes, which cells dilate as the liquid

*See *The Canadian Engineer*, June 25, 1914, for an article entitled "The Method and Work of the Emschergenossenschaft," by Prof. P. Gillespie, C.E.

Data Concerning Two-Story Sewage

	Date of Completion	Population for which designed	Number of Tanks	Radial or Longitudinal Flow	Open or Covered	Depth	Flowing through time	Mean Velocity in Sedimentation Chamber	Capacity of Sludge Room
Carleton Place, Ont.	1914	4,000	2	Longitudinal	Covered	26 ft.	3 hrs.	3 ins. per min.	6,000 cu. ft.
Edmonton, Alta.	Not Started	10,000	2	Longitudinal	Covered	24 ft.	2 hrs.	7.2 ins. per min.	22,000 cu. ft.
Hamilton, Ont.	1914	70,000	4	Longitudinal	Open	28 ft.	2½ hrs.	21 ins. per min.	6 mos. accumulation
Kelowna, B.C.	1913	3,000	1	Radial	....	23 ft.	2 hrs.	....	2,750 cu. ft.
Peterboro, Ont.	Not Started	....	8	Longitudinal	Covered	27 ft.	½ hr.	29 ins. per min.	42,700 cu. ft.
Stratford, Ont.	Under Construction	17,000	2	Longitudinal	Open	24⅔ ft.	1¾ hrs.	....	21,400 cu. ft.
Weston, Ont.	1913	3,000	2	Longitudinal	Covered	18 ft.	2 hrs.	4.8 ins. per min.	1,500 cu. ft.

is absorbed. When such sludge is applied to a bed, only the coarser particles remain on the surface. Owing to its fluidity, much of the finer material penetrates into the interstices in the medium, some of it indeed passing all the way through. The surface layer becomes more and more dense through the accumulation of particles of sludge which penetrate it successively with new applications until finally it becomes impervious.

"The rotting process, however, produces a radical change. The colloids are broken down. The sponge-like structure with amorphous cell walls referred to, disintegrates and loses in the act, its capacity for holding water. In the second place organic matter, such as fragments of animals and plants which are very common in household waste, is destroyed. These substances which have naturally a very large water content, are found in very small quantities if at all in decomposed sludge, so that the difference in the water content between fresh sludge and decomposed sludge must to some extent be regarded as a measure of the completeness of the decomposition.

"The most important element making for the separation of water from decomposed sludge is the contained gas. The gas in decomposed sludge under thirty feet of water sustains a pressure substantially twice that which acts upon it when it comes to the surface. Immediately on release of the water pressure, the confined gas swells and the sludge becomes frothy and foamy. The water being heavier, sinks to the bottom, passes down through the medium and drains away. This phenomenon may be illustrated in a very simple manner. If a glass beaker of decomposed sludge freshly drawn from an Emscher tank be permitted to stand for a few hours, it will be observed that the light and gas-containing portion will rise to the surface, incidentally increasing the depth. Meanwhile, the clarified water will have settled to the bottom. An examination of the floating matter shows the presence of many gas sacks or cells. In the course of time, a portion of the sludge, having lost its gas content, will sink to the bottom, thus indicating that this sludge, without the increased buoyancy given it by entrapped gases, is heavier than water. If, on the other hand, fresh sludge be placed in another beaker, its solid contents will settle to the bottom, and if it be examined later, it will be found that the separated water is at the top instead of at the bottom. In this lies a most important difference.

"Accompanying the destruction of the colloidal and organic matter, is a partial decomposition of the fats. In European sludges the fat content will average ordinarily 15% of the dried constituents."

The difference between good and bad sludge is defined; the effects of metallic salts upon sludge and of acid-forming ingredients are observed.

The paper goes on to enumerate the recommendations of Prof. Hyde and Mr. F. E. Daniels as essentials to be observed in the operation of a sewage treatment plant:—

1. If the velocity in the feeding channels be not sufficiently high to be self-cleansing, the deposits should be swabbed out semi-weekly in summer and less frequently in the colder season. If they become septic they are a source of disagreeable odors. Such deposits in feeding channels in which the flow is periodically reversed, are more likely to be found at the inlet end because of the diminished velocity there.

2. With equal frequency, too, should the sides and sloping floors of the sedimentation chamber be cleared of adhering matter. On floors of flat slope and rough finish the accumulation is most rapid; on others it is less so None are entirely immune. Instances have occurred in which the slots leading to the sludge digestion chamber have been completely choked by this matter. Ebullition of gas from the upper chamber is evidence that it has begun to septicize. A long-handled squeegee should be employed to clean the surfaces and to push with the least disturbance possible, the accumulations into the chamber below.

3. The tendency on the part of scum to collect in gas vents is well known. Since this scum must have been previously heavier than water, its later buoyancy is due in the main to the entrapped gases of decomposition. It will be seen that an existing scum tends generally to become thicker since particles that float up adhere to the mass of accumulations already floating and remain. Otherwise on losing their gas content, they would sink again. Scum formation tends to be greatest where evolution of gas is greatest. This state occurs usually in the comparatively early history of the life of plants when a mass

Sedimentation Tanks in Canada

Hydrostatic Head on Sludge Outlet	Sludge-Drying Area	SUPPLEMENTARY PLANT	Separate or Combined System	Capacity of Plant, Gallons per day	Cost of Plant exclusive of Sewers	DESIGNER	REMARKS
5 ft.	1,200 sq. ft.	Chlorination plant, sludge beds	Separate	1,080,000 (Imp.)	$8,800	T. Aird Murray and T. Lowes, Toronto	Sewage is chlorinated before entering tanks
6 ft.	4,680 sq. ft.	Grit chambers, sludge beds	Combined	1,500,000 (Imp.)	$35,0[illegible]0	Eng. Dept. City of Edmonton, A. J. Latornell, Chief	Filters to be added. Reversible flow
6 ft.	10,900 sq. ft.	Screens, grit chamber sludge pump, sludge beds, percolating filter (future).	Combined	5,880,000 (Imp.)	$70,000	A. F. Macallum and B. E. T. Ellis, Hamilton	Flow is reversible
12 ft.	625 sq. ft.	Grit chamber, pumping station, force main, sprinkling filters, sterilizer, secondary settling plant, sludge beds	Separate	270,000 (Imp.)	$15,000	A. K. Mitchell, Victoria	Vent is provided over central stack. Cost given is exclusive of pumping station
7 ft.	60,000 sq. ft.	Pumping plant, sprinkling filters, final settling plant, sludge beds	Separate	[illegible],000,000 (Imp.) maximum	. .	R. H. Parsons, Peterboro	Sterilizing plant may be added
$7\frac{2}{3}$ ft.	....	Screens, grit chamber, sprinkling filters, sludge beds	Both	1,350,000 (Imp.)	$15,500	A. B. Manson, Stratford	....
6 ft.	1,050 sq. ft.	Percolating filters, secondary settling tanks, with sub-irrigation sludge beds	Separate	540,000 (Imp.)	$19,000	Murray & Lowes, Toronto	....

of sludge has accumulated, most of which is in active decomposition and none of which, or practically none of which, is as yet decomposed and inert. Insufficient scum area or gas vent area will intensify the trouble.

Excessive depths should not be permitted, and need never occur if the scum is persistently broken up from time to time as it forms. A garden rake, or better still, a pressure hose will accomplish this satisfactorily, and since much of the entrapped gases are permitted thereby to escape, the bulk of the material will sink to the bottom. It has been observed also that the occasional discharge of water under pressure through the flushing pipes in the sludge digesting room will mitigate the scum evil. Materials which defy all attempts to settle should be skimmed off and buried or burnt. This last statement applies also to floating materials which are always observable near the baffles and along the walls of the sedimentation chamber. It should not be forgotten that if sewage fresh on its arrival at the works is to be found still fresh on its discharge from the sedimentation tank, its contained solids with their ready capacity for decay must not be permitted to lodge or remain in the upper chamber.

4. In tanks designed for the purpose, reversal of flow should be made monthly.

5. Determinations of the depth of sludge in the lower chamber should be made weekly. This is very conveniently done by lowering through the gas vents by a gradual cord, a disk of No. 20 B. & S. sheet steel, of diameter 15 inches, suspended at three points, so that its plane is horizontal. Its weight in air is about two pounds. The surface of the sludge can be rather closely ascertained through the support which it affords to the disk. The surface should not be permitted to rise higher than 18 inches below the slots at the bottom of the sedimentation chamber. It is observed that when this rule has been disregarded ebullition of gas is often observable in the upper chamber. This phenomenon is doubtless due to the fact that the stratum of mobile and gas-charged liquid overlying the sludge proper has been sufficiently thick to submerge the slots and thus permit some of the escaping gas to enter the settling chamber.

6. If the tank be supplied by pumps whose capacity exceeds the inflow of sewage and which in consequence must operate intermittently, the quantity pumped at each operation should not exceed, and preferably should be less than the volume of the sedimentation chamber.

7. Care must be exercised in the drawing off of sludge that neither fresh sludge nor the overlying sewage be permitted to escape. Thoroughly rotted sludge can always be detected by its color and smell, especially the latter. When a sludge gate is opened, there is always a tendency for the sludge in the immediate vicinity of the lower end of the discharge pipe and whatever overlies it, to be forced out by the weight of the water above. This results from the fact that the semi-liquid mass moves vertically in the centre of the sludge pit with less friction than it can move in the inclined direction along the sloping floor. In consequence, the sludge occupying the figure of an inverted cone lying over and above the lower extremity of the pipe is first forced out, and if care be not taken the liquid above this will soon follow. To avoid this, only small quantities of sludge should be drawn at a time. After the gate is closed the sludge mass will find its level again, especially if the flushing pipes previously referred to be brought into service. The water escaping from these has the effect of assisting and lubricating the movement of the rotted sludge down the slope of the chamber floor toward the extremity of the sludge outlet pipe. Sufficient of the contents of the sludge digestion chamber should be left to insure continuity of the rotting process.

8. To prevent the sludge pipe becoming filled with solidified sludge, after each drawing off, the pipe should be filled from its upper end with water. Similarly if all sludge chambers are cleansed after use with water under pressure or otherwise, both appearance and operation of the plant will be improved. Water under pressure is a great convenience for operating pressure rings in the sludge room, for backfilling sludge discharge pipes after use and for cleansing sludge channels. In cases where secondary sedimentation tank sludge is to be pumped back to the primary sedimentation tank, the pumping unit may be arranged to handle clarified effluent which may then be utilized for the various purposes for which water under pressure may not be available.

9. The depth of sludge run on to drying beds should not exceed 12 inches. After drying, its depth is reduced to about 6 inches. To facilitate the passage of water downward, care should be taken that the surface of these beds has not become clogged through too constant and continuous use.

A description of the Kremer apparatus, providing a method to remove the grease which the sewage to be treated contains, is also given.

Prof. Gillespie gives some very interesting descriptions of typical plants, including Bergedorf, near Hambourg; Essen-Nord; Atlanta, Ga.; Schenectady, and others. A section of the paper is devoted to a discussion of Dr. Imhoff's patents in the United States and Canada, and another to the reception in America of clarification tanks of the Emscher type. In concluding his remarks thereon, the writer states:—

"When it is considered that the Emscher tank has been tried out for seven years in Europe and for three years in America, it is safe to say that it is well past the experimental stage. The history of its operation on these two continents, and the testimony of engineers who have studied it at close range, constitute its vindication. The list of municipalities which have either installed or prorose to install it in America, furnishes additional evidence as to its reception on this side of the Atlantic. While it does not represent a method of disposal complete in itself except in special instances; while it is not easy to construct, is not fool-proof in its operation, and is not either initially or afterwards the least expensive of the appliances from which the engineer may choose, it offers, in the opinion of the writer, the most satisfactory solution for the troublesome sludge problem which up to the present has been proposed."

His paper closes with a list of places in America in which the 2-story sedimentation tank has been or is to be installed. From his list we extract the following as a list of installations in Ontario: Barry Tannery, Bowmanville, Carleton Place, Copper Cliff, Cornwall, Dundas, Guelph Prison Farm, Hamilton, Leaside, New Liskeard, North Toronto, Oakville, Peterborough, Port Arthur, Rockwood Asylum (Kingston), Simcoe, Stratford, Toronto, Vankleek Hill, Vineland Canning Co. (Vineland), Weston, Whitby, Whitby Hospital for the Insane.

The other Canadian installations are: in Saskatchewan, Battleford, Canora, Humboldt, Regina Jail, Saskatoon, Kamsack, Estevan and Battleford hospital; in Alberta, Calgary and Edmonton; in British Columbia, Kelowna and Vernon.

ECONOMICS OF ELECTRIC RAILWAY DISTRIBUTION.*

By Horace Field Parshall, D.Sc.

PRACTICALLY all modern traction systems of the larger class are referable to the same class of power house and transmission system, and these are not affected to any important extent by the sub-station arrangement, which is determined with reference to variations in the operating result occasioned by the spacing of the capacity of the individual sub-stations.

In the book by Mr. Hobart and the author on "Electric Railway Engineering," most of the problems entering into the design of electric railway installations have been dealt with. The question of the economic arrangement of sub-stations and the distribution conductors was not dealt with at length, because at the time the book was written sufficient operating data were not available to furnish a basis for different calculations. Such a wide difference of opinion existed between different engineers as to the cost of operating and maintaining a system of sub-stations that it did not appear advisable to treat the subject except on general lines. Since the publication of that book a great deal of experience has been gained, as a result of which engineers have come into more general agreement as regards sub-station practice. The present paper is written with a view to assist towards the standardization of electric railway sub-station practice. Many years ago Lord Kelvin formulated a law as to the economic use of conductors in transmission systems. The number of independent variables when a complete system with sub-stations has to be dealt with is so great that the mathematical expression, from which might be deduced the minimum cost, would in practice be open to some suspicion. In this paper a complete balance-sheet embodying every item has been worked out for each case, and the tabulated result is included as a part of the paper; hence, for different conditions it would be possible for an engineer to make the necessary corrections, so that, without any great amount of labor, the methods and results of the paper may be applied to practically any class of electric railway installation. The paper has not been extended to include the electric traction installation as a whole, since the process of standardization in respect of motor equipments is still proceeding, and conclusions that might be drawn under present conditions would in another short time be incorrect. So far as the distribution is concerned, the conclusions are likely to be lasting, since the operating conditions on which the general results are founded are likely to obtain for a considerable time to come.

With the given energy-consumption per unit of length of line that follows from a given train-movement, the capacity of the substances increases indirectly with the distance between them. The energy-loss in distribution-conductors of a given section varies with the cube of the distance between sub-stations. The cost of attendance is within wide limits independent of the size of the sub-station. The cost of the plant per kilowatt falls off with the size of the units, but the maintenance and renewals per kilowatt are more or less constant. The paper embodies a series of curves showing graphically the arrangements of substations that will operate different train services on different electrical systems and at various voltages with a minimum total operating cost. With rotary-converter sub-stations and a working voltage of 600 volts, and for certain assumed average conditions of train-weight, speed, and energy-consumption, the most economical sub-station spacings are 8½, 5½ and 3¼ miles for train services of 6, 12 and 24 trains per hour respectively. For a working voltage of 1,200 volts the sub-station spacings are 11, 7½ and 5 miles respectively, while when 2,400 volts is adopted the most economical sub-station spacings are 16, 12 and 8½ miles for the three train services respectively. Curves are also given illustrating the advantage gained by working at higher voltages, and these confirm the author's view that with the present arrangement of rotary-converter sub-stations, there is little advantage in a higher voltage than 2,400 volts for the track conductor. The economy of higher voltages is shown to be approximately the same whatever the train service. As between 600 and 1,200 there is a saving of 14 per cent. in the total annual costs of the distribution system; as between 1,200 and 2,400 volts there is a further saving of 7 per cent., or 21 per cent. as between 600 and 2,400 volts. If the working voltage is further increased to 3,600 volts, there is a decrease in total annual expenditure on sub-station and overhead conductor equipment of only 3 per cent., which will be less than the additional cost of the rolling stock.

For single-phase distribution at 5,000 volts the most economical sub-station spacings are 31, 24 and 16 miles for train services of two, three and six trains per hour respectively. At 10,000 volts single-phase, the most economical sub-station spacings are 45, 34 and 26 miles for the same three train services respectively. With three-phase distribution at 5,000 volts the most economical distances between sub-stations are 38, 31 and 18 miles for the same respective train services. In most of these last cases, however, the economical distance between sub-stations thus determined is greater than would be permissible in practice from considerations of both traffic operation and voltage drop. Further, in the case of single-phase operation, the lower pressure of 5,000 volts is found to be the most economical for certain services and the higher pressures of 10,000, 12,000 and 15,000 volts in vogue on the continent are explained by considerations of voltage drop.

*Abstract of a paper read at a meeting of the Institution of Civil Engineers of Great Britain, Nov. 17, 1914.

POWER SURVEY OF CANADA.

The Commission of Conservation is compiling data respecting power used in the Dominion. A circular has been issued to power users and manufacturers requesting information regarding the consumption of power. The questions asked cover the field fully, embracing water power, electric power, steam power, gas engines, and oil engines, and each division solicits answers which, if given with any degree of enthusiastic co-operation, should place the Commission in the position of being able to compile information that will be found of great value by Canadian engineers and manufacturers. It is to be hoped that those to whom blanks have been sent will furnish the fullest possible information and that any of our readers who may not have been approached by the Commission, will apply for a blank to the Assistant to Chairman, Commission of Conservation, Ottawa. The compilation entitled "Waterworks of Canada," published in December, 1912, has proved of signal value, and it is to be expected that the data which the Commission has now set itself the task of collecting, will have an even greater field of usefulness throughout the country.

CONCRETE CONSTRUCTION AT CEDARS RAPIDS, QUEBEC.

ON December 17th the Canadian Society of Civil Engineers will have under discussion at its general meeting the paper read at a former meeting (October 22nd, 1914) by Mr. John E. Conzelman, chief engineer of the Unit Construction Co., Montreal. This paper had to do with the system of unit concrete construction employed in the erection of the power house and transformer stations of the newly completed hydro-electric plant of the Cedar's Rapids Manufacturing and Power Co. *The Canadian Engineer* has presented, in previous articles, the general details of design and construction of this development, and we abstract herewith some notes on the above method of construction, from Mr. Conzelman's paper, believing it to be one conducive to some very interesting and valuable discussion.

For the essentials of the layout our readers are referred to issues of this journal for January 1st, 1914, and July 9th, 1914. It will be remembered that the superstructure of the power house is built over the dam and that it is of structural steel frame construction with reinforced concrete floors, walls and roof. It was originally intended to construct the walls of brick, but unfavorable transportation facilities, etc., effected a change in the plan, the result being a decision to use concrete throughout.

The power house is about 643 ft. long x 125 ft. wide, with 35 bays 16 ft. 8 in. long and 3 special bays 18 ft. 4 in. long. Fig. 1 shows the typical section. The exterior walls are 12 in. thick, consisting of two independent 4-in. concrete slabs with a 4-in. air space between. The steel columns were provided with slots to receive the slabs (which were lowered down from the tops of the columns) and after two opposite slabs had been set, they were held apart by a piece of one-inch plank which fitted into notches in the slabs. This board also served as a form for the grout which was poured into the space between the column and the slabs. The purpose of this grout is to hold the slabs in place and also to protect the columns against corrosion. The construction is shown in Fig. 2.

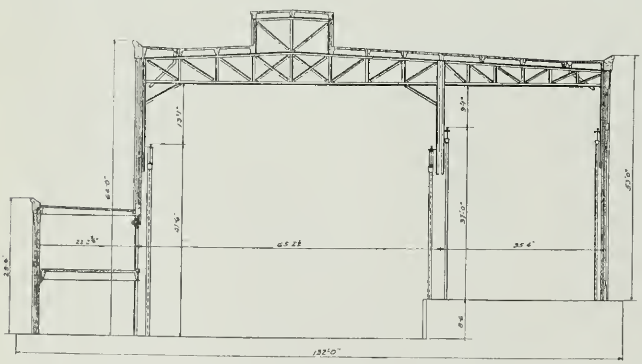


Fig. 1.—Section Through Power House, Cedars Rapids, Quebec.

Fig. 1 shows the form of roof construction. The roof units consist of a reinforced concrete plate 3 in. thick cast integral with the beams, which are carried around the four sides. The units are 16 ft. 6½ in. long and 16 in. deep over all. The entire unit acts as a beam between trusses; the reinforcement in the beams acting as the tension flange and the entire slab providing compressive strength. A uniform distribution of load on the trusses is assured by the stiff end beams of the units, and the mortar bed upon which the units are set. The roof units are so dimensioned that a space one and a half inches wide is left between the ends and over the centre line of the trusses. These spaces, as well as the spaces between the slabs themselves, are filled with grout. Reinforcing

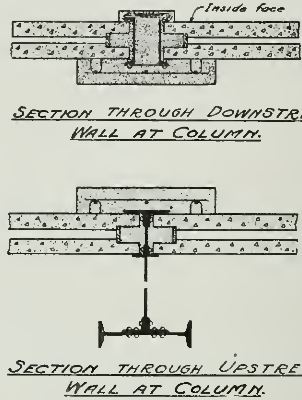


Fig. 2.

bars 3 ft. long are placed in the space between the units and extending over the trusses. These fars form an effective tie after the grout has hardened. Concrete saddles were formed on the roof for the purpose of directing the water to the downspouts. The roof covering is 4-ply Barrett specification material mopped directly to the concrete.

The steel work was erected by the Phœnix Bridge and Iron Works Co., Montreal. The roof trusses are designed to carry a load of 100 lbs. per sq. ft., and the crane girders and main aisle columns are designed to carry two electrically operated travelling cranes of 150 tons capacity. The high columns were spliced at the level of the crane girders. All connections, except the butt joint between the ends of the crane girders, were riveted. One expansion joint was provided.

Erection of structural steel and concrete units was done by means of a structural steel stiff-leg derrick mounted on a triangular steel tower 60 ft. in height with an 80-ft. boom. The weight of the heaviest steel member was about 5¾ tons and of the heaviest concrete unit, 8 tons. Each unit was provided with lifting hooks or bent steel bars for the purpose.

The reinforced concrete transformer house is a 4-story building with basement, and is supported on spread footings with concrete curtain walls. The foundations rest on hard clay about 7 ft. below grade, and each footing carries a load of approximately 4,000 lbs. per sq. ft. Fig. 3 is a typical section. The building is 228 ft. long and 88 ft. wide. It comprises 10 bays 20 ft. long and 4 bays 7 ft. long. A special column spacing was necessary as the transformers are arranged in groups of three. Instead of the typical spacing of 20 ft. and 7 ft., as noted above,

a length of 47 ft. was divided into three equal spaces of 15 ft. 8 in. Above the third floor typical spacing was used.

Heavy construction was used in the ground floor to support transformers estimated to weigh 75 tons, together with handling equipment necessary for their installation. The upper floors were designed for a live load of 250 lbs. per sq. ft., except where special loadings occur. The roof is designed for a load of 100 lbs. per sq. ft.

In this building the exterior walls are of concrete slabs 10 in. thick with a 2-in. air space, formed by means of a sand-core which was washed out before the unit was set. The basement walls are 12 in. thick and of reinforced concrete.

The concrete units were brought to the building on flat cars from the unit yard located some distance from the site. The casting yard was provided with a track about 400 ft. long down the centre from which a locomotive crane with a 50-ft. boom handled distributing buckets of controllable discharge type to forms disposed on each side of the track for a width of 50 ft. The effective area of the casting yard was 36,000 square feet.

There are 3,916 units in the power house and 1,602 in the transformer house, the total amount of concrete being 6,111 cu. yd.

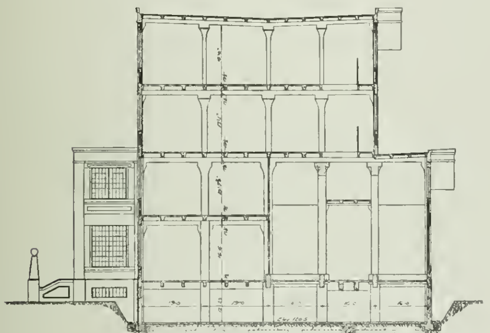


Fig. 3.—Section Through Transformer House.

In his paper Mr. Conzelman presents some very interesting information respecting details of unit construction and laboratory tests covering them. In closing he claims as a chief advantage for the method the fact that the units may be made under what may be called factory conditions. The forms can be strongly built and carefully bedded. The system provides for easy inspection and test, if desired, before incorporation into the intended structure. The reinforcement is easily held into proper position. There is also more certainty, according to the writer, in a unit design as the loads are carried by a definite system of units, and the joints occur exactly where a designer wants them. Although unit methods are not advisable for all reinforced concrete structures, they were recommended by Mr. Conzelman for those consisting of a series of similar bays involving considerable duplication of parts. Again, as in the case of the Cedars Rapids power house, it is often advantageous to cast the units sometimes before foundation is ready to receive the superstructure.

At the recent convention in Jacksonville, Fla., of the American Public Health Association, the convention city for 1915 was chosen to be Rochester, N.Y.

ENGINEERS FROM THE CONTRACTOR'S VIEWPOINT.

IN an address delivered to the Albany Society of Civil Engineers, Mr. Richard W. Sherman, chief engineer of the New York State Conservation Commission, notes the impossibility of complete harmony existing always between engineers and contractors, and attributes this to the fact that they represent opposing interests in a considerable degree. The engineering graduate starts with an educated prejudice against contractors, whom he believes to be, in the main, determined to get the best of engineers, and therefore he is on his guard and purposes not only to take care of himself but to get the best of the contractors.

Contractors dread the "boy engineer" just from college. These young engineers are extremely technical. They expect a literal compliance with every iota of the contract obligations by the contractor.

With rare exceptions, men greatly improve in learning, wisdom and disposition as they grow older. After 20 or 30 years, a man is surprised to find how little he knew when he started his professional or business career. He has grown in riper judgment, and has developed greater caution, discretion and justice toward others. He grows considerate, amiable and kind.

Contractors are largely influenced by their opinions of engineers. The engineer who has a reputation for ability, honesty, fairness and good disposition will attract bidders for any work of which he has charge and the desire to do work under him would be an incentive to reasonably low prices. It is a feature of contracting to "size-up" the engineer with as much accuracy as possible.

In bidding for work, contractors are almost as sensitive as weathervanes. It may be possible to make a profit at a given bid under one engineer and impossible to avoid a loss under some other engineer, with all other conditions similar and the quality and the merits of the work constructed being equally good at the same cost to the owner in each case.

A majority of bids are too high. The highest bid is often twice as much as the lowest even when the lowest is sufficient. Over-anxiety to secure the contract is the commonest cause of low bidding. Low bids are often made to keep a contractor's organization together for future work on which he hopes for better prices.

Contractors who do not care for the contract often bid fairly high up, without any expectation of securing the contract but merely to avoid a reputation among contractors of being low bidders, and with the bare chance of getting the work at good prices. Excessively high bids are usually the result of lack of knowledge of the value of the work and lack of time to become familiar with it.

If an engineer's preliminary estimate is believed to be too low, it drives away bidders and tends to indifferent, high bidding. Some over-anxious contractors may be influenced thereby to bid too low. They may secure the work, in which event the engineer has an unpleasant task during construction. There is almost sure to be a disposition on the part of the contractor to save himself from loss and he is thus tempted to slight the quality of the work. Both contractor and engineer are in some degree injured by the work having been done at less than cost.

An engineer who can make reliable preliminary estimates will find his services in demand by municipalities, corporations and other owners, or if he chooses to practice as a contractor's engineer, he will find his services of

great value in that field. Some prominent engineers of my acquaintance would not under any circumstances do engineering work for contractors, confining their services entirely to the owners. I know of other engineers who confine themselves wholly to engineering for contractors and who do a large business as engineering experts for contractors, in litigations.

These two fields of engineering are becoming more and more distinct and it is my opinion that an engineer is wise who makes his choice and adheres strictly either to the one line of practice or to the other.

The contracts and specifications on very large and important works usually are models of perfection. In smaller works, such as may amount to, say, not over $200,000, contractors are often confronted with bidding papers, contracts, specifications, plans, etc., which are a disgrace to the engineer who drew them.

There are a few engineers who are sometimes called "specification fiends." They write to many places, where work is advertised, for specifications, etc. They read them eagerly and often clip such paragraphs as catch their fancy—usually those which are harsh, severe and unreasonable from a contractor's standpoint. With these clippings to aid them, they draw up specifications, etc., which often deserve the name of "crazy-quilt" specifications.

Such papers are full of contradictions, useless paragraphs and ambiguities which are almost sure to cause contention and trouble during construction and in the final settlement, or lead to litigation. Such engineers are apt to insert severe conditions such as excessive cash deposits with the bids, unreasonably short time in which to construct the work, excessive per diem liquidated damages for overtime, excessive bonds and sometimes excessive retained percentage where monthly payments are provided. About all they can think of is to make the work undesirable and objectionable to contractors. Such engineers and their work are often avoided by the best class of bidders and the contracts are apt to go to rather undesirable contractors.

PROGRESS ON QUEBEC BRIDGE.

At the annual meeting of the Dominion Bridge Co. held last week it was stated that on December 1st about 42 per cent. of the steel for the superstructure of the new Quebec bridge had been fabricated, and about 18 per cent. erected. It is anticipated that the work will be finished in good season, and within the original estimates of cost.

INVESTIGATIONS OF EXPLOSIVES USED IN COAL MINING.

The United States Bureau of Mines have carried on a number of investigations into the nature of the explosives used in mining operations, with a view to changing the character of explosives so as to meet the needs of the various branches of mining, and especially to increase safety in coal mines. Both the improper use of explosives and the use of improper explosives have resulted in coal-mine disasters. The investigation of explosives is also important to metal miners, whose health and efficiency are seriously affected by the use of improper explosives, but the bureau has not yet had the facilities for taking up a thorough investigation into this latter phase of the subject.

THE STRIPPING, QUARRYING AND MINING OF GYPSUM.*

THE methods employed in the exploitation of gypsum deposits are generally of the simplest. The operations consist of stripping, quarrying or mining, and transportation. There are, however, several important points that have to be taken into consideration when opening up a quarry, which, if not considered, would be liable to seriously handicap an operator in competition with his neighbor. A deposit of gypsum may be everything that is desired in the way of quality and extent, but still may not be capable of being worked economically on account of its distance from shipping facilities, ready market, and also its heavy overburden. Its location also with respect to the drainage of the surrounding country may necessitate a heavy expense in keeping a quarry free from water, so that this factor has in some cases to be taken into account. Another factor that influences the operation of a quarry is the availability of a steady supply of labor. When steady labor is obtainable, better work can naturally be accomplished, and new and improved methods can more readily be taught the quarrymen when they are working continuously instead of spasmodically.

Methods of Stripping.—The amount of overburden resting on the gypsum beds which it is desired to exploit, has a great bearing on both the method of operating the quarry and its successful development. Where there is a rock covering over the gypsum and also a deposit of drift material, the stripping of the deposit is out of the question, and mining methods are employed, but where the overburden consists of only soft material, it is generally more economical to remove this overburden and to extract the gypsum by open quarrying. In order to remove this material, great expense has to be entailed, it costing at the present time from 20 to 25 cents per cu. yd. to remove such material. When operations are undertaken on a sufficiently large scale to warrant the use of a steam shovel, the cost of stripping is between 15 and 20 cents, but where only a small quarry is to be opened, and the stripping has to be done by hand, the operator has to consider very carefully what depth of an overburden he can reasonably afford to remove, as in many cases the cost would be so excessive that a quarry could not possibly be worked at a profit.

The methods of stripping usually employed in gypsum practice are: Hand, horse scrapers, and steam shovel.

It is only in very small quarries, or where the material to be stripped is very light, that the work is done by hand. The work has naturally to be carried on during the summer months, as the frost would make the price during the winter months prohibitive. When the dirt is removed by hand, it is shovelled into carts and hauled to the nearest dumping ground, or else it is allowed to cave into the quarry and then sorted from the gypsum and carted away. This latter practice is greatly to be condemned, as the loose waste cannot help getting mixed with some of the white rock, impairing its value for plaster manufacture. It is a practice that is, however, very prevalent, even among some of the larger operators, and is only due to the fact that the Canadian gypsum is of such a high grade that no notice has so far been taken of it.

*From "Gypsum in Canada," prepared by L. H Cole for the Department of Mines.

The horse scraper method has been employed successfully in the deposits in northern Manitoba to remove overburden. These horse scrapers are similar to those used by railway contractors in railway construction work. The nature of the deposits there lends itself admirably to this mode of operation. The surface covering in these northern deposits consists of about 3 feet of clay and loam, loosely cemented together by gypsum, and this material readily breaks up before the scraper, and can then be hauled and dumped into any of the numerous sinkholes which are scattered through all the deposits. This has proved a very satisfactory method for the removal and disposal of the waste material.

In the larger quarries, the steam shovel is gradually coming into use for the removal of the waste material which lies on top of the gypsum. Only in late years, however, have these appliances been employed to any extent. Where the overburden is of any great thickness, the waste material is removed in benches by the steam shovel working on the top of the deposit. In that case a track is generally laid alongside the shovel, and the shovel loads directly into cars, which can then be hauled to wherever the best dumping ground is available. This method proves satisfactory to a certain extent, but considerable material is allowed to fall into the quarry, there to be removed by hand, or else by a second shovel. A second method, sometimes employed, is to remove the overburden over a bench of gypsum, to operate the shovel on top of this bench, and then clean off this bench by hand and carts. This method leaves the greater portion of the gypsum free from danger of being mixed with the waste material.

Hydraulic Stripping.—In many of the gypsum deposits of Nova Scotia and New Brunswick the overburden which rests on the gypsum is of considerable thickness. The present method of removing this waste material is, as already stated, by hand labor, horse scraper, or steam shovels, and this entails a great expense, and in many cases materially reduces the small margin of profit upon which the quarries are operated, or actually causes their shutting down. As this overburden is in all cases composed of loose material, it would seem that stripping of the gypsum beds by the hydraulic method would not only, in many of the quarries, be feasible, but would also greatly reduce the time required and the cost in handling. In order to bring this matter to the attention of the gypsum operators throughout the country, Mr. Cole inserts the following notes on hydraulic methods in his report:

Conditions Required.—Unlike the methods required and employed by most of the large hydraulicking companies of the west, hydraulic methods, when used for the purpose of removing the surface coverings to enable the rock underneath to be mined or excavated, have to be greatly modified to meet the altered conditions. In the first place, the wash from the monitors does not have to be saved, and hence the material can be conveyed in sluices greatly simplified from those which have to be prepared for the gold-bearing gravels. The shortest and most convenient form of sluice leading directly to the dumping ground will answer the purpose, regardless of slope (or grade) or curves.

Then, again, in most cases, when used for the stripping of gypsum, the nozzle pressure of the water would have to be obtained by means of a high pressure pump of large horse-power, and although this would be the greatest expense of the whole installation, it would do away with an extensive and expensive flume or pipe line, as the contour of the country is not such as to enable a high head of water being obtained except by this means.

The supply of water required would be one of the greatest factors in the installation, but this, in most cases, could be overcome by using the water over and over again.

The matter of a dumping ground for the waste material would be one of considerable difficulty, especially where the material was to be sluiced directly to it, but if no convenient place were available for direct sluicing, the waste material could be readily handled by a pipe line and a relay of centrifugal pumps, which would place it in any of the old abandoned quarries nearby.

In phosphate mining in Florida, hydraulic stripping is being employed to great advantage, at a cost of from 5 to 8 cents per cu. yd. of material moved. In the same district, where steam shovels are employed, the cost is 20 cents per cu. yd.

A modified form of hydraulic stripping is being made use of by the Nipissing Mining Co., of Cobalt, Ont. There it is employed to wash the surface covering of drift from the rock, in order to examine the rock closely for the small veins which sometimes would be overlooked by ordinary trenching. A turbine pump is employed, guaranteed to throw 4,800 gallons of water per minute, under a head of 415 ft., through a 3½-in. nozzle. The pumping plant consists of a 675-h.p. turbine pump connected directly to a motor. The water is piped to the point required, and is there forced through a 3½-in. nozzle at high pressure. A space is first cleared by this means, after which the ground is sluiced down in benches, thus, as soon as a certain section has been examined, it is covered over again with the tailings from the section above. The ground slopes gradually towards Cobalt Lake and the water drains back again into the lake from which it is pumped in the first place.

The application of hydraulic stripping to gypsum overburdens is very simple. The water is obtained from the nearest and most constant source of supply and is forced through a pipe line by an approved form of pump, so that a pressure of from 90 to 150 lbs. per sq. in. is obtained at the nozzle of the monitor. A nozzle which delivers a stream of water at the required pressure is placed conveniently near the overburden to be removed, and the stream playing on the soft drift soon disintegrates it and it is then sluiced away by the running water to the dumping ground. If no dumping area is available near at hand, the sump method can be employed, where a sump is made in the floor of the quarry at a convenient spot and the waste material all washed into it. A series of centrifugal pumps and a pipe line are easily installed to keep the sump empty and remove its contents to the nearest permanent refuse pump.

Installation Required.—The following list will cover practically all the machinery and material required for stripping by the hydraulic method: (1) Pumps (*a*) high pressure pump, (*b*) centrifugal relay pumps; (2) pipe lines (*a*) mainpipe line, (*b*) discharge pipe line; (3) monitor (nozzle); (4) sluices; (5) special ball and socket joint, etc.; (6) operating motors and power.

In Mr. J. A. Barr's article on Florida phosphate practice (M. and M., Dec., 1912, p. 265) he gives the following paragraph descriptive of the present practice in pumping machinery in Florida for this type of work:

"The earlier and present universal practice is to use direct acting compound or triple expansion pumps for furnishing water to the hydraulic nozzles at the mines and to the washer. The Florida Mining Co. has a triple ex-

pansion pump capable of furnishing 4,000 gallons of water per minute, which it delivers at a pressure of 150 pounds per square inch. The Prairie Pebble Co. uses a somewhat similar pump made by the Worthington Co. Their pumping plant consists of three triple expansion, duplex, direct acting pumps, size 12 in. x 19 in. and 30 in. x 17 in. x 24 in. These pumps have a capacity of 2,800 gallons per minute each.

"The only centrifugal pumping plant that supplies water to the pipe nozzles is installed by the new French company. This company uses a three-stage turbine pump, direct connected to a 250 horse-power induction motor, and it delivers water to the nozzles at a pressure of 140 pounds per square inch. The experience with this pump in the field has been that when new, it was very satisfactory, but when pumping gritty water, such as must be the case in most of the mines, the pump lining soon wears, and the pump has a low efficiency.

"The newest pumping stations being built contain the Corliss flywheel condenser pump. The principal advantage of this pump for this kind of work over the direct acting pump is principally its high duty, which often is at least one-third more. The duty of the direct acting pump seldom goes over 90,000,000 gallons, while that of the Corliss flywheel pump approximates 120,000,000 gallons in 24 hours. The flywheel pump is less liable to become broken by the failure of the governor to act, or by bursting of the pipe line."

Where the waste has to be transferred from a sump to a dumping ground at a distance, the pumps employed are generally centrifugal pumps of an approved type. To obviate the trouble always encountered when two or three of these pumps are operated in tandem, the best practice is now to make each pump in the relay act independently by delivering into a series of sumps from which the following pump draws its supply.

Pipe Lines.—For the pipe line for the delivery of the water to the nozzles, a 10-in. steel spiral pipe is being employed, and this has been found to work very satisfactorily. There is, however, no reason why other styles of piping could not be used. For the last few hundred feet of piping before the nozzle is reached, a 6-in. flanged, spiral riveted, galvanized water pipe is employed.

When the pipe line is used for removing the waste material from the sump, any approved kind of piping that will stand the wear and tear of gravel, etc., passing through it, can be employed.

Nozzles.—Any of the smaller types of hydraulic monitors that are in use in gold hydraulicking methods can be employed in stripping. From 3½ in. to 4½ in. in size would suit.

Sluices.—The sluices for hydraulic stripping can be of the simplest type, and in many cases no sluice is required at all, as the natural gullies in the rock will be sufficient to carry the waste material to the required dumping ground. Generally small trenches are dug, or else temporary sluices are built which very well answer the purpose.

Special Ball and Socket Joints, etc.—In order to facilitate the easy moving and handling of the monitor from place to place, a special form of ball and socket joint is generally employed in the 6-in. pipe. Several of these are placed in a length of from 400 to 500 ft., and this gives the nozzle sufficient play so as to cover a large territory. Several other special attachments are required, such as a joint to keep the pump from being broken by water hammer, and special suction pipes, etc.

Power and Motors.—The question of power for operating the pumps is a matter of considerable interest. In many of the properties electric power could readily be generated, and current delivered to the motors, which are directly connected to the pumps. Where coal is cheap, steam could be used for generating this power. In some localities, water power could be obtained.

Quarrying or Mining.—The consideration of the best means of the exploitation of gypsum is a matter which up to the present time has not been a serious factor in the development of a deposit. In the maritime provinces, and also in the west, the largest deposits of gypsum are all comparatively near the surface, with only a covering of loose material which can easily be removed, but which would not hold up if undermined. Consequently the only method in most cases is to remove the gypsum by open quarries. This method has a number of advantages over underground mining, which have been greatly to the benefit of the gypsum operators. These advantages may be stated as follows:

(1) Easier supervision. A better idea can be obtained of the class of material that is being quarried.

(2) Better ventilation, as the men are always working in the open air.

(3) Easier handling of the gypsum.

(4) No timbering is necessary, and all the material can be extracted, as no pillars have to be left.

Its disadvantages are few, the principal one being the exposure to all the different kinds of weather, thus hindering the work, and the danger of exposure of the men to heavy rain, snow, or extreme cold.

Quarry Work.—As a rule most of the quarries operating in gypsum have no regular shape, and nowhere does any systematic method seem to have been employed. It has generally been a case of taking the gypsum from wherever it occurred, without any regard to future economy in working. In consequence many of the quarries are just a series of pot holes, with no two parts of the quarries alike. Thus much time is lost by the repeated handling of the gypsum, when in many cases one handling would be sufficient.

The present practice is to obtain as high a face as possible of clean gypsum, and to break it down by caving. This is accomplished by drilling the lower part of the face with auger and hand-power drills, and then blasting the holes with a low-power dynamite, generally about 40 per cent. strength. This brings down a large tonnage of gypsum, which is then broken up by hand sledgehammers to a convenient size for handling. The broken material is hand picked, so as to remove any pieces of anhydrite or foreign matter, and is loaded into small cars or dump carts and hauled either to the mill or wharf direct, or else where there is a railway line, to the nearest siding, where it is dumped into the railway cars.

In the gypsum deposits of northern Manitoba, a steam shovel is being employed successfully to handle the gypsum, thus doing away with the excessive handling which is so frequently met with in gypsum practice throughout the country. After the surface is stripped, the gypsum, which is of a soft variety, is drilled by a series of vertical holes placed regularly at 8-ft. intervals across the working face of the deposit. These holes, when blasted, shatter the gypsum sufficiently so that it can be handled by the steam shovel directly into the standard railway cars, standing on a siding beside the shovel. This method is found to be cheap and economical, and enables a large tonnage to be got out in a very short time.

In all of the gypsum quarries in Canada, the drilling is accomplished by hand power, one-man auger drills, similar to those employed in coal mining practice. They are found to work very successfully, as the gypsum is soft and drills easily. No attempt seems to have been made to install power drills of any sort.

Mining Methods.—Where the overburden is excessive, and consists of a rock capping over the gypsum beds, the deposits are generally operated by underground methods. On account of the small price obtainable for the gypsum, the simplest and cheapest methods have to be employed. The present practice in Canada in gypsum mines seems to be to open up the deposit by an incline tunnel, generally at a slope of 15° to 20°. Why this special method of entrance has been adopted in preference to a vertical shaft is not clear. In the earliest gypsum operations in the country, the deposits were opened up in this manner, and the custom has been to follow the example of these first attempts.

When the bed of gypsum has been reached, main haulage ways are laid out, and the gypsum is recovered by a room and pillar system similar to that employed in coal mines. Tracks are laid to the face in these chambers, and the broken gypsum is loaded directly into cars, which are then taken by hand, or horses, to the main haulage way, where they are made up into trains preparatory to being hauled up the incline by a small hoist. Considerable loss is caused by the fact that the pillars in most cases are composed of good gypsum, which would otherwise be recovered.

Transportation. — Transportation facilities in the quarries are of the simplest nature. In most of the operating quarries in the east, the broken gypsum is loaded by hand into single horse Scotch carts, and taken by them either to the shipping pier, or to the nearest railway siding. This necessitates a great deal of extra and useless handling of the rock before it reaches its final destination. Much time and labor might be saved if a system of radiating tracks were laid through the quarry, and the cars loaded directly at the face.

The method of transporting the loaded material from the quarry to the mill or shipping pier, is, in most cases, by narrow gauge railways, and this affords easy and cheap handling.

Drainage.—Gypsum quarries, as a rule, are seldom troubled with water, but in some places, especially where the level of the floor of the quarry is near the level of the water table of the surrounding country, the problem of handling the water has to be taken into consideration. In this case a sump is located in the lowest part of the quarry, into which all the water collects, and a small duplex pump, generally stationed somewhere well protected from the blasting, is sufficient, being operated only a few hours each day, to handle all the drainage from the whole quarry. In cases where the quarry is below the drainage level of the surrounding country a larger pumping plant has to be installed.

DRILLING HARD STEEL.

To drill a hard piece of steel without having clearance wear off the lip of the drill, which necessitates repeated grindings, hold the drill firmly in a vise and with a light hammer strike the face or cutting edge at the outer corners, raising a light burr. This makes the drill cut enough over size for easy clearance, and it is surprising how much wear it stands. It is much better than grinding off centre, and is especially handy in drilling small dies.

THE MECHANICAL ELIMINATION OF SEAMS IN STEEL RAILS.*

By Robert W. Hunt,
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THE increased weight of rolling stock and speed of traffic has necessitated increasing the size of the rail sections, and hence their weight; as many of the details of rail manufacture have been changed with such alterations, it is not surprising that new and unexpected physical weaknesses have developed in the heavier rails. One of the most notable has been the failure through crescent-shaped pieces breaking out of the rail flanges, followed by at least one, and in many cases several, ruptures across the whole section of the rail. Investigation has showed that in practically every instance of such failure there was a more or less pronounced seam running longitudinally in the bottom of the rail near its centre, and thus immediately under its web. This seam occurs at the top of the curve of the crescent-shaped break and is undoubtedly the point at which the fracture starts.

Those familiar with steel rail making have known that it was practically impossible to make rails entirely free from seams, and that as the seamy conditions of the steel forming the head of the rail increased, its wearing quality would decrease, but I think it was not until the disastrous experiences with the "moon-shaped" failures that the danger from seams in the base of the rails was fully realized. It is true that rails with actual flaws in their flanges have been rejected as first-quality ones and that a very pronounced seamy condition of the bottom of the rail would also cause its rejection. Such rejections were the cause of frequent disputes between the mill operatives and the inspectors, the point being as to how far the inspectors were warrented in carrying their condemnation; but, as already said, it was not felt that a single seam would be dangerous unless very pronounced.

The crescent-shaped breaks were of such frequent occurrence that they indicated a very serious condition and led rail makers to experiment with the design of their rolling passes, with a view to obviating the formation of the bottom seams. It was found that fewer seams were produced by such changes, but they were not entirely eliminated. While more or less successful in preventing the formation of seams through lapping on the bottom of the rails, the formation of seams in other parts of the section was not particularly affected.

T. H. Mathias, assistant general superintendent of the Lackawanna Steel Company, determined that the most certain way of getting rid of seams was to remove that portion of the metal which contained them, and, as applied to steel rails, thus to eliminate them from both the base and head of the rail. Mr. Mathias reasoned that the primary causes of seams existed previous to any rolling of the steel, in fact, were incident to the casting of the molten metal into ingots. He knew that disk-like apertures were formed on the sides of ingots while the molten metal was being cast and were probably caused from air being entrapped against the sides of the ingot molds by the hot steel as it raised in the molds, a condition which was not controlled in regular manufacturing routine. It will be appreciated that, as the section of the ingot is reduced and elongated in the rolling process, so,

*Abstract of a paper read at the annual meeting of the American Society of Mechanical Engineers, New York, December 3, 1914.

of course, will the apertures be stretched longitudinally and thus be formed into seams.

Mr. Mathias demonstrated that there is another constant condition present in the rolling of large steel ingots, in the formation of a decarburized surface, about 5/16 in. deep on all four faces, and containing from eight to ten points lower carbon than the metal immediately under it, the decarburized envelope undoubtedly being produced through the oxidizing conditions to which ingots are subjected in the soaking pits where they are heated preparatory to rolling. A thick oxide scale is always formed on the surface of ingots in the pits, so that conditions are invariably present for the production of such a layer of lower carbon metal on their outside faces.

Mr. Mathias was convinced that during the process of rolling ingots into rails it was practical to remove mechanically the parts of the enveloping steel which would form the top of the head and bottom of the flange of the rail, and experimented accordingly. He designed and his company installed as an addition to their rail train, a milling, or hot-sawing machine, to cut off that metal without retarding the regular operation and thus interfering with the production of the mill.

The ingot is reduced in the blooming rolls to an 8-in. by 8-in. cross-section, and after cropping the ends the bloom is further reduced in the roughing or shaping stand of rolls by five passes. When it leaves these rolls, it is approximately 75 per cent. finished and at this period it is carried to the right and entered between two pinch rolls with its base or flange side up. A bar which will make four 33-ft. rails is about 60 ft. in length at this point in the rolling operation; therefore, the area of metal to be cut off or removed in the milling machine is approximately ⅛ in. deep, 7 in. wide and 60 ft. long. It is driven through the pinch rolls at a rate of 60 ft. in 30 seconds. The pinch rolls have a draft of about ⅜ in. and thus force the bar between the two milling saws, which are so arranged in the housing that they may be raised or lowered as desired. From 1/32 in. to 3/64 in. of metal is milled from the head and base of the bar, the front end of which, immediately on passing from between the rolls, is caught by a second set of pinch rolls which have a draft of about 1/16 in. These pinch rolls force the bar between the tools, pull it from between them, and also hold it in practically perfect line for the milling operation. The milling apparatus is driven electrically and requires about 600 h.p. for its operation.

As the milled dust or particles of steel are thrown out, they are hit by water under pressure which forces them into a chute and also prevents the material from adhering together. They are carried below the mill, through this chute, and are caught in boxes or receptacles suitable for charging as scrap into the open-hearth furnaces.

The milling tool is 5 ft. in diameter with an 8-in. face and revolves at a peripheral speed of 2,500 ft. per minute, thus causing an engagement of about 400,000 teeth per minute on the hot rail bar. The teeth are of 0.80 carbon steel, and it has been demonstrated that they will mill at least 30,000 tons of material without requiring dressing.

The milling on the flange does not reach the extreme edges of the bar, and on the head side does not affect the corners. Either by a modification of the shape of the piece as presented for treatment in the milling machine or, what will probably be more practical, changing the face of the tool, the milling can be extended to the extreme edge of the flange portion of the bar and somewhat around the corners of the top or head side. This will undoubtedly be perfectly practical and thereby eliminate the seams which may be located in those parts of the bar. The primary object has been to eliminate the seams from the central portion of the bottom of the rail which had been the starting point of the moon-shaped failures, and to remove them from the top or bearing surface of the head of the rail. Personally I think it will be desirable to extend the milling by the use of convex-faced tools.

The work of rolling which the steel receives after the removal of the more or less laminated metal, must produce a better product than if such elimination had not taken place, and it should not only make them less liable to breakage on account of seams in their flanges, but also enable them better to resist the abrasive effects of traffic.

During the many years of my connection with rail making I have examined a great many etched specimens of rails, not only directly in connection with the process under consideration, but for various other reasons. From such experience I can fully appreciate what Mr. Mathias has accomplished. The surfaces of practically all rails, when etched, will show some seams on both the base and head, and very frequently the extent of such defects will not be appreciable if the scale has not been removed. Even then, it is not always an easy or certain matter to estimate the depth of the seams. When the rails have been subjected to the Mathias milling operation and still show pronounced seams, it has been found that breaking tests will practically always develop the fact that the suspicious marking is an actual seam.

As the original defects on the sides of the ingots vary in extent, so will the character of the resulting seams vary, and it can be readily appreciated that some of them may have been too deep to have been completely eliminated by the milling.

While I have confined myself to the matter of steel rails, it is patent that the process will be of great value in the preparation of blooms for axles and all other kinds of forgings. As is well known, it is practically the universal custom to endeavor to remove the seams developed in rolling axle billets by chipping them out through the use of pneumatic hammers, and for some of the higher characters of forgings, notably for automobile parts, the endeavor to eliminate the seams is carried to the extent of turning off the whole surface of the billets. I am confident that by the Mathias plan the greater part, if not all, of such work can be superseded, and I regard the invention and its practical installation as a notable achievement in the art.

WORK OF THE U.S. BUREAU OF MINES.

The chief work of the U.S. Bureau of Mines during the four years since its establishment has been the investigation of problems having to do with the causes and prevention of coal-mine explosions and the safeguarding of the lives of coal miners. In addition, work has been done on the testing of coal and other mineral fuels belonging to or for use of the government of the United States. During the past fiscal year investigations were undertaken looking to greater safety and the prevention of waste in the metal-mining and miscellaneous mineral industries of the country. Recently a small amount of work has been done in an examination of several oil and gas fields of the country with a view to eliminating the large waste of natural gas in these fields. The need of such investigations may be plainly seen when it is understood that so large a part of this waste is easily preventable, that the supplies of natural gas are limited, and that the gas wasted yearly may be fairly valued at not less than $50,000,000.

ELECTRIC ARC WELDING.*

By J. H. Bryan.

ELECTRIC arc welding as a commercial process may be divided into two general classes: (1) Benardos or carbon electrode process in which the arc is drawn between the metal to be welded and a carbon electrode. (2) Slavianoff or metal electrode process in which the arc is drawn between the metal to be welded and a metal electrode.

These two processes are generally spoken of as carbon electrode and metal electrode welding respectively.

In addition to these there is the Zerener process, in which the arc is drawn between two carbon electrodes, as in the arc lamp, and the metal to be welded is placed in contact with the arc. This is, however, not considered a commercial proposition in this country, as its field of application is limited, and the apparatus itself is unwieldy.

Quoting from C. B. Auel in the "American Machinist" (1911): "In carbon electrode welding the metal to be welded is made one terminal of a direct current circuit, the other terminal being a carbon electrode. Upon closing the circuit by bringing the carbon electrode into contact with the metal and then withdrawing it to a distance, an arc is drawn between the two terminals. Through the medium of the arc, which is the hottest flame known (having a temperature between 3,500 deg. and 4,000 deg. Centigrade—6,300 deg. to 7,200 deg. Fahrenheit), the metal may be either entirely melted away, molded into a different shape or fused to another piece of metal as desired."

The metal electrode process of welding is a somewhat later development than the carbon electrode method, and differs from the latter in that a metallic electrode is substituted for the carbon.

If direct current is available from a shop or commercial circuit, welding can be done directly from this source of supply, but this method has been found to be very wasteful of power and should not be resorted to except where welding is only to be done at very infrequent intervals. An additional disadvantage of the use of the shop circuit as a source lies in the fact that, unless arrangements are made for insulating the work from ground, the shop circuit is grounded, with attendant danger to other employees in the shop, as well as to the welding operators. A much more economical method is that of using a motor generator set, the motor being constructed with characteristics suitable for operation on the shop or other circuit, and used to drive a low voltage generator. The generator may be either shunt or compound wound, the shunt wound machine being satisfactory where only one arc is to be operated, while the compound wound machine is preferable if several arcs are to be supplied from the same unit. Experience has shown that generators giving a potential of 75 volts or thereabouts will enable satisfactory results to be produced. As different welds require different strengths of current, it is at once evident that there must be some means of regulating the current supply. This is usually effected by inserting resistance in the welding circuit connecting it in series with the arc.

A suitable electrode holder must be provided for both carbon electrode and metal electrode welding. Protective equipment is necessary for the operator on account of the fact that the exposure to the rays of the arc causes an irritation and subsequent peeling of the skin if the exposure has been sufficiently long, say several minutes. The irrigation is very similar to sunburn and is uncomfortable, but no serious consequences ensue, and at the end of a few days all traces of the burn disappear.

When the carbon electrode is used, the filling material is usually of the same metal as that being worked upon and may be used in any convenient form. When metal electrodes are used for welding iron and steel they should be of best quality of soft iron or steel wire and may range in diameter from 1/8 in. to 1/4 in. The length most generally used is about 12 in. Copper, bronze and brasses with a low percentage of zinc may also be welded by this process, in which case the electrodes should be of the same material as that being welded. Where the zinc content of brasses is high, it volatilizes to such an extent as to make the work porous and brittle.

The current required for carbon electrode welding varies from a minimum of about 200 amperes to a maximum of around 700 amperes, or even more in very heavy work. In general, however, 300 or 400 amperes have been found to be sufficient for ordinary carbon electrode work.

The metal electrode process, though a considerably later development than the carbon electrode method, has a field of application very distinct in many cases from the older process. Its principal advantage is on work where it is desirable to localize the heat to the greatest extent possible, thus minimizing strains due to expansion and subsequent contraction. An example of this is in the welding of sheet metal or of a broken bridge in a flue sheet. Another advantage of this process is that it enables welding to be done in a vertical plane or even from the underside of the piece to be repaired. With the metal electrodes much lower currents are used than in the carbon electrode process. The maximum value hardly ever exceeds 150 to 175 amperes. For a greater portion of the work a current of about 100 to 130 amperes is found satisfactory, although the amount of current required will vary with the size of the electrode and the class of work being done.

The carbon electrode process is also well adapted for cutting of metals. In cutting the arc is drawn just as in welding and is played along the line to be cut, provision being made for the melted metal to run off. Very rapid work of this sort can be done, especially if heavy currents are used. The heat generated varies approximately as the square of the current so that a comparatively small increase in current will give a considerable increase in the rapidity with which work may be done.

Among the principal uses of arc welding equipment in steam railroad shops are the following: Flue welding; firebox repairs; frame repairs, and building up of worn parts. Besides these there are innumerable minor tests for the equipment.

General practice varies as regards the best method of welding flues. The time of welding will probably average 15 per hour, although as high as 25 per hour have been reported. This time is for 2-in. flues. Five-inch superheater flues are being welded at about one-fourth this rate. It is interesting to note that the flue sheet is found to be in better condition upon removal of flues than is the case where flues have not been previously welded in. This is due to the fact that the welding builds up the sheet around the flue holes to about the original thickness.

*Abstract of a paper presented before the Western Railway Club, November 17, 1914.

Closely related to flue welding is the subject of firebox repairs. The defects to be repaired include cracks in the side, flue, door and crown sheets, leaky staybolts, leaky seams, etc. Also sheets will often be found to be in such condition that repairs are impossible, and it is necessary to put in patches. All of this class of work can be done very satisfactorily by the use of the arc welding equipment. Broken locomotive frames also are very satisfactorily repaired by the use of the electric arc. One railroad (R. F. & P.) reports that it has in service at the present time 65 welded locomotive frames and has had only one failure; this failure was attributed to the fact that the arc weld was in close proximity to one made by another process.

The following figures are taken from records of actual repairs made in a large railroad shop in the middle west at various times, the figures given being a comparison between the actual cost of welding and that of putting the apparatus back into service by methods previously used, either by replacement or by repair of the old parts. The arc welding costs were based on a power cost of 51 cents per hour for the carbon electrode and 17 cents an hour for the metal electrode, together with cost of labor and an overhead charge of 40 per cent. The power costs used are slightly higher than those usually obtaining in shops of this nature:

	Cost of welding.	Cost by other methods.
Plugging 51 holes in expansion plate, holes 1 in. diam. by ⅝ in. deep...$	2.75	$ 10.15
Repairing mud ring	6.50	34.57
Cutting four 6-in. holes in tender deck sheet ½ in. thick	1.08	8.35
Welding eccentric strap, broken through neck	1.08	41.28
Repairing mud rings	6.50	24.57
Welding two spokes in driving wheel centre	7.98	99.98
Welding cracks in bulkhead in tender tank	2.33	8.00
Welding cracks in side sheets	26.15	31.79
Repairing firebox	134.89	869.58
Building up flat spots on locomotive driver	.40	225.00

No hard and fast rules can be laid down as to the size of outfit required, as no two installations will be alike in their requirements, and the matter of selection of apparatus of proper capacity is largely one of judgment and experience. In steam railroad shops installations are usually made of sufficient capacity to take care of not less than four to six operators, and the larger shops can occasionally use even greater capacities to advantage. Where a greater number of operators are to be supplied, however, it is generally found to be more economical to install additional outfits in other sections of the shop where welding is to be done, rather than to put in one large central plant. This is on account of the fact that as this work is usually more or less scattered the cost of line copper becomes an item for consideration.

Arc welding is not to be considered as a panacea for all the ills that the metal worker is heir to. There are many classes of work for which it is entirely unsuitable, but its range of usefulness is so wide that it has long since fully justified its existence.

BITUMINOUS MACADAM BY THE COLD MIXING METHOD.

SINCE 1906 the Rhode Island State Board of Public Roads has constructed a large amount of bituminous macadam by the cold mixing method. Much of it has been down sufficient time now to admit of some definite conclusions regarding the success of this type of construction. We feel that some of our readers will be interested, therefore, in the paper read by Irving W. Patterson, chief engineer of the board, at the Atlanta Road Congress, this paper giving a résumé of the work since its beginning, 8 years ago. The writer draws conclusions regarding the adaptability of the cold mixing method, based upon his experience with work of this type.

The first attempt made by the State highway authorities of Rhode Island to avoid the deficiencies characteristic of plain waterbound macadam construction by the incorporation of a bituminous binder was upon the Post Road, which is subjected to the heavy through automobile traffic between the famous shore resorts of Rhode Island and the large cities to the south and west. A traffic census upon this road taken during 1913 showed an average summer travel of approximately 600 vehicles daily, consisting very largely of motor vehicles. The construction work upon this section was carried out during midsummer of 1906.

At that time there was little reliable information concerning bituminous macadam available, so the exact methods of carrying out the work necessarily had to be decided upon more or less arbitrarily. It was decided to use a crude tar as a binder and to incorporate this material with the road metal by the cold mixing method. The mineral aggregate employed in the mix was crushed stone of sizes which were retained upon a one-half inch screen and which passed an inch and one-half screen. The stone employed was native field and wall stone, which is a rather coarse-grained, somewhat kaolinized granite. The metalled surface was constructed 14 feet wide with a crown of three-quarters of 1 inch per foot. All rolling was accomplished by means of a 10-ton, 3-wheel steam roller.

The construction in brief was as follows: Crushed stone which was retained on an inch and one-half screen and which passed through a 3-inch screen was first spread over the well rolled sub-grade, to a depth of 4 inches after compression. This course was not filled with sand or stone screenings but was well rolled. Crude tar was very lightly sprinkled over this first course of stone. Crushed stone of the sizes stated previously was then mixed with crude tar in the proportion of 15 gallons of tar per cubic yard of stone. Mixing was carried out upon a portable wooden mixing platform placed as closely as convenient to the point where the mixture was being spread. The mixture of stone and tar was spread over the first course of crushed stone to a depth of 2 inches after compression. The mixture was well rolled, after which a covering of stone screenings was applied.

No foundations and no sub-drainage were deemed necessary upon this work because of the stable character of the gravelly sub-soil encountered.

The results secured upon this first experimental section of bituminous macadam were remarkably successful. No repairs have been required to date. The surface today is perfectly intact and presents a perfect mosaic appearance, due to the top surfaces of the stones in the mixture being all in evidence.

In 1907 a much longer section of bituminous macadam was constructed. The method was almost identical

with that employed the previous year. The results secured upon the section built in 1907 were inferior to the results secured in 1906. The surface began to ravel slightly in 1912, and during that year a seal-coat of refined tar was applied. To-day the surface is somewhat irregular and a few breaks are in evidence, although the riding qualities of the road are very fair. The relatively inferior results secured from work in 1907 is attributed largely to a less stable sub-soil.

It will be noticed from the foregoing that no seal-coat was applied at the time of construction. Subsequent experiments have proved the advisability of seal-coating. The marked success of this early work in spite of the absence of a seal-coat is due largely to the character of the travel. The horse-drawn traffic over both of the above sections is very light. The blows of horses' shoes upon the exposed surfaces of the soft stones would be destructive if horse-drawn traffic occurred in any considerable amount.

In 1908 bituminous macadam by the cold mixing method was taken up to much greater extent. Various experiments both in materials and methods were carried out, and to-day it is evident that these experiments were largely negative in results produced. Many materials and combinations of materials were tried which did not give satisfaction, and no work noticeably superior to the work of 1906 and 1907 was done. Results approximating those secured in 1906 and 1907 were secured, however, upon sections constructed in the same manner as were the bituminous roads built those years. Perhaps the greatest failures in the work during 1908 were upon sections where tar products and asphalt products heated in separate kettles were used in combination as a binder for the top course of crushed stone. Where this combination of binders was employed, ravelling started the following year and increased in extent very rapidly as time went on. In 1913 a heavy seal-coat of asphalt was applied to several of the roads bound with a combination of tar and asphalt and the results secured from this treatment appear highly satisfactory.

In 1909 some very interesting experiments were carried out and these experiments produced some very positive results. It is true that there was work done in 1909 according to methods tried out in 1908 and since proved unsatisfactory, but at the date of the construction of the 1909 work it was not to be ascertained for a certainty what of the 1908 work was satisfactory and what was not, due to the short time the work had been done.

Upon the Nayatt Point Road in the town of Barrington the most interesting and valuable experiments of the year were carried out. The section of this road selected for the experiments offered excellent opportunities for experimental work because of the remarkable uniformity and excellent stability of the sub-soil encountered. Foundation troubles have not been responsible for any of the defects which have developed in any of the experimental sections. These experiments have been completed long enough now that certain definite conclusions may be drawn from them. (Mr. Patterson's paper then presents in detail the chief features of experiments carried out at Barrington in 1909. Their insertion here is precluded for want of space, and only the materials used are given. Experiment 1.—Crude tar and asphalt in mix with asphalt seal-coat; trap rock. Experiment 2.—Same, with native stone instead of trap. Experiment 3.—Refined tar in both mix and seal-coat. Experiment 4.—Asphalt in both mix and seal-coat. Experiment 5.—Refined tar with 20% asphalt in mix and seal-coat. Experiment 6.—Same, but with only 10% asphalt in both. Experiment 7.—All refined tar in both. Experiment 8.—Refined water-gas tar. Experiment 9.—Crude tar in mix, asphalt seal-coat. The paper then goes on to draw the following conclusions.)

These experiments seem to prove that certain forms of the cold mixing method are very satisfactory upon roads subjected largely to motor vehicle traffic. Only two of the sections have necessitated repairs of any account during the five years they have been laid. Both of the sections requiring repair were laid with the same combination of binders, and the much greater extent of repairs necessitated upon the section constructed of trap rock is of interest in consideration of mineral aggregates.

It was shown conclusively that a seal-coat of asphalt is much more permanent than a seal-coat of refined tar, although both the crude tar and the refined tars gave excellent results as far as their binding of the mineral aggregate is concerned. The effectiveness of refined water-gas tar is also proven. The section built of this product is superior at present to either section built of refined coal-tar.

Bituminous Macadam Subsequent to 1909.—In 1910 the typical construction employed was a mixture of crude tar and crushed stone, seal-coated with a heavy asphaltic product. This construction is identical with the construction employed in Exp. 9. The facility with which the crude tar could be handled and the good results secured with this material previously, accounted for its extended use in 1910. The results secured with this type of construction in 1910 were very successful. With one exception these roads have required only the lightest of repairs to date, the exception noted being located upon the main street of a large village and constructed of 2¼ and 1¼-inch trap rock. This road had disintegrated somewhat by the spring of 1911, and from that time on the disintegration rapidly became greater in extent. By the spring of 1913 the condition of the surface was serious. Several breaks of 10 sq. yd. or more in area appeared, and small breaks were very numerous. It was decided to patch the breaks with a mixture of ¾-inch trap rock and refined tar and to apply over the entire surface a seal-coat of asphalt covered with clean ½-inch trap rock screenings. Asphalt of approximately 15 mm. penetration was applied at the rate of ½ gal. per sq. yd. of surface and covered while hot with screenings, which were rolled with a 6-ton tandem roller as soon as possible. This work was done in June, 1913. The results of this treatment have proved very satisfactory, no further ravelling having taken place to date.

Mixing in 1910 was accomplished by the hand-mixing method upon wooden platforms.

In 1911 no appropriation for road work was made and consequently no bituminous macadam was constructed.

In 1912 an attempt was made to duplicate in effect the excellent results secured in 1906 by the use of crude tar by employing a comparatively light refined tar. It was the express intention to apply to the roads built with this refined tar a seal-coat of asphalt as soon as need for such treatment was evidenced, thereby securing eventually the same type of road which was so eminently satisfactory in 1910. Mechanical mixing was introduced for the first time in 1912. The type of mixer employed upon practically all of the work was a cube mixer of approximately one-half cubic yard capacity fitted with a heating device. The stone was not heated previous to mixing, the heating device being employed merely for the purpose of keeping the inside of the mixer warm so that it would not become

clogged. The stone employed was both local 1½-inch stone and commercial 1¼-inch trap rock. The results secured with the local stone averaged superior to the results with trap rock.

The results secured in 1912 were variable. In 1913 it was deemed necessary to seal-coat with asphalt approximately 42 per cent. of the total area of the roads constructed in 1912. During 1914 approximately 6 per cent. of the total area was seal-coated with asphalt. The roads which have not been seal-coated are in very good condition at present, but the necessity is anticipated of applying a seal-coat to all of them during the next two construction seasons. The seal-coating of the work done in 1912 has been very effective to date, but it is as yet too early to draw conclusions regarding the results of the 1912 work after seal-coating as compared with the results secured in 1910 where the seal-coat was applied at the time of construction.

During 1913 the amount of bituminous macadam constructed by the cold mixing method was small as compared with the amount constructed in 1912. Two methods were employed. The type of construction employed in 1910 was taken up to some extent with a refined tar in place of a crude tar—a seal-coat of asphalt being applied at the time of construction in exactly the same manner. An asphalt of characteristics similar to the asphalt employed upon Exp. 4 was used to some extent in both mix and seal-coat. The work by both methods has proved perfectly satisfactory to date, although the construction is so recent that definite conclusions cannot be drawn. Trap rock was employed satisfactorily in the mix for the first time during 1913. The commercial ¾-inch size of trap rock was employed in place of the commercial 1¼-inch size which was previously used, and this product has given excellent satisfaction to date.

It has been proved that the utmost care in constructing bituminous macadam by the cold mixing method is necessary. The crushed stone must be perfectly dry at the time of mixing and all stones must be perfectly covered with bitumen in order that good results may be secured. The manner of carrying out the rolling is also important in its effect upon the results obtained. It is, of course, necessary to secure by rolling as compact a mass as possible, but considerable care must be exercised in regulating the time and amount of rolling. If the weather is cool at the time of construction, the heavy rolling should be postponed until mid-day, when the maximum warmth is experienced, although the initial rolling is done as soon after the mixture is laid as possible.

The character and sizes of the crushed stone employed are also of great importance. We have secured the best results, as far as stone is concerned, with our native rock, which is rather variable in character. As a rule, this native rock is softer than trap rock and breaks with a much more irregular fracture than trap rock. There is more or less breaking of the native stone by rolling, and this appears to be beneficial rather than otherwise in that a denser pavement is secured. We feel that if trap rock is employed, smaller sizes are necessary than with a softer stone, unless there is a certainty of securing a perfect crusher-run from 1½-inch to ¼-inch or less.

We have experimented with heating the aggregate previous to mixing, but these experiments seem to show that inferior results are secured as compared with the results obtained with the same materials where the aggregate is unheated. The aggregate in bituminous macadam contains at best a large percentage of voids, and in the heated aggregate there was noted a tendency upon the part of the binder to run off from the stones, leaving only a very thin coating upon each stone. In several cases, for instance, 18 gallons of binder per cubic yard of stone were necessary to cover all stones in our unheated mineral aggregate, but when the aggregate was heated, 12 gallons would cover all stones and there would be considerable bitumen which would run through the mineral aggregate and be lost. The tendency for the bitumen to cover a heated aggregate very lightly seems to be due to the fact that the heat retained by the stones does not allow the binder to become hard for a considerable time, with the result that it continues to run for some time. We recognize that it is necessary to heat the aggregate in a dense mixture such as a bituminous concrete pavement affords, but in bituminous macadam work by the mixing method we prefer a cold aggregate or an aggregate heated but slightly.

The weather conditions influence the results obtained in bituminous macadam by the mixing method considerably. We have noticed that roads built late in the fall just before freezing sets in are not apt to be as satisfactory as those built in mid-summer, even though the temperature at the time of construction is not low. It seems to be a decided advantage to roads built by this method of construction to have a comparatively long period of warm weather immediately after construction in order that the surface may become freed from the top covering of stone screenings and well smoothed out before snow and ice appear. In Rhode Island we consider the season most favorable to this type of construction to be between the middle of May and the middle of October.

Upon the whole, the cold mixing method of constructing bituminous macadam as practiced in Rhode Island appears to be an economical pavement for motor vehicle traffic. It does not appear to the writer as suitable for heavy horse-drawn traffic or for a heavy mixed traffic. The traffic upon several of the trunk lines in Rhode Island consists of motor vehicle traffic to the extent of over 90 per cent. of the total amount of traffic, and it is upon these roads that we expect in the future to confine our bituminous macadam roads built by the cold mixing method. Through large villages where the percentage of horse-drawn traffic is large, we expect to take up a stronger method of construction.

GOVERNMENT WHARF AT REVELSTOKE, B.C.

The Department of Public Works, Ottawa, has commenced the construction of a wharf at Hall's Landing, Revelstoke. It is 30 ft. wide and 280 ft. long, and is estimated to cost $55,000. It is to be constructed of timber piles.

The Dominion Government will also spend this winter $4,500 on mattress work for the protection of the bank of the Columbia River, near the site of the wharf. The mattressing will start at the end of the wharf and extend 400 yards down the river. The work of construction will start as soon as the water has fallen sufficiently to allow of mattresses being placed.

RAILWAY CONSTRUCTION ON THE GOLD COAST OF AFRICA.

It is estimated that the extension of the Gold Coast Railway from Komfrodna to Kumasi will cost about $6,000,000. The first section, to Komfrodna, will probably be opened early next year.

A SIMPLIFIED METHOD FOR THE LOCATION OF SIDINGS.

By W. F. French in "Railway Age Gazette."

A SUPERVISOR frequently has need of a simplified method by which the curves of a siding may be laid out on the ground, either at the time the preliminary survey is made, with the object in view of showing the applicant for the siding the salient features of the location or of making notes necessary to an estimate of the grading, when a tape line layout may be the only one possible, or at a later time when the siding is about to be constructed and a transit may be unobtainable or its use inconvenient. Doubtless many cases require some instrumental work and it is then useful to know how the processes can be simplified, as the corps will generally consist of the supervisor or his assistant and a trackman or two.

It is thought that probably the greater number of cases of siding layout can be met by the use of the tape line alone. Most supervisors carry with them at all times a 5-ft. extension rule and a 50-ft. steel tape and not a few a 100-ft. length of string to correct the general line of curves. By the aid of the simple rules of geometry and with the use of the accessories mentioned, it is possible to dispose immediately of very many cases and often avoid the necessity of a subsequent visit to the location.

The matter is greatly simplified by the fact that the right-of-way line is nearly always parallel with the tracks and the building which fixes the location of the siding is also parallel. The siding, therefore, is either parallel or at right angles with the track. But even for those cases where the siding is not parallel or at right angles with a tangent main track a special solution is possible which is not unduly complicated and which can be comprehended by most maintainers of track.

It is not claimed that any new theories have been developed, but is it claimed that certain of the solutions offered are not to be found in any of the field books. Of the many which are to be found there only those have

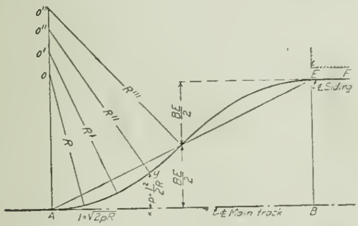

Fig. 1.—A Siding Parallel to the Tangent Main Track.

been selected which tend to simplify the supervisor's work and even to open the way for the safe handling of such problems by the brighter track foremen, not a few of whom are now entering the ranks of supervisor.

It will perhaps be thought by some that in neglecting the tangents introduced into the siding curve by the straight switch and frog accuracy is being sacrificed, but it will be found that for turnouts above No. 5 (and those below have been practically eliminated by the operation of the Safety Appliance law) no sensible error will result from this source. Stakes need not be set at either the point of switch or the point of frog, but their location should be indicated by marks on the rail and care should be taken that the half inch point of frog is always understood.

The simplest case is that of a siding parallel with a tangent main track and flanking a building, the location of which fixes the maximum offset distance. There is no practical need nor is there usually the space for introducing any tangent between the curves, but in order to render the physical conditions at the point of reverse as favorable as at the beginning and ending of the curve, it is quite advantageous to make the curves flatter at the reversing point. This may be done by using the formulae

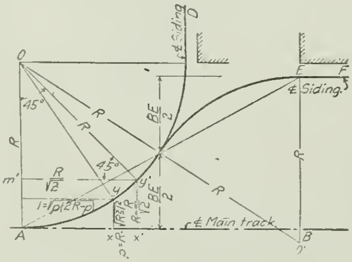

Fig. 2.—A Siding Parallel to or at Right Angles to the Tangent Main Track.

for the parabola. While this increases the length of the curve somewhat, the extension is not more than a few feet even for an extreme case.

The formulae symbolized are $p = \dfrac{l^2}{2R}$ and $l = \sqrt{2pR}$, or expressed in words signify that for a chosen distance from the point of the curve along the tangent, the offset is equal to the square to the distance divided by twice the radius, or conversely, for a chosen offset from the tangent, the linear distance is equal to the square root of the product of the offset multiplied by twice the radius. The field books employ these formulae for staking out a circular curve by offsets from the tangent and chords produced, the value of the offset from the chord produced being twice that from the tangent, when the distance used is a chord of the curve instead of a length on the tangent. The method is undesirable because the operation of successively producing the chords renders the process subject to cumulative error.

By the use of the formulae in the manner suggested, the distance from the end of the curve to the reversing point and from the reversing point to the point of switch may be obtained at once. These distances will be equal if the two curves are of equal radii and the reversing point will be midway between the line of the main track and of the siding. Whether the curves be of equal radii or otherwise, this point will lie in the line joining the two tangent points. Any number of intermediate points on both curves may be set after computation of the offsets. Those for the second curve may be made supplements of the whole distance between the siding and the main track and thus all the measurements be made from an actual base line and every source of error in the field work be eliminated. It should be noted that the offsets vary as the square of the linear distance and if the distances selected are in a simple ratio, the square of this ratio multiplied by the first offset will supply the other offset with a considerable saving in computation.

When the length of radius is not absolutely determined by limiting conditions, as indeed seldom is the case,

one should be chosen which will make the offset at the point of frog equal to the gauge. This radius will be about 5 per cent. larger than the actual radius obtaining through the lead, but this advantage is quite desirable both from the maintenance and operating standpoints. This solution may be used for the case of a crossover between two tracks which are parallel, but which are so far separated that a tangent between the frogs is impracticable.

If it is preferred to make the reversed curves circular rather than parabolic, the formulae outlines for a continuous circular curve should be employed.

The problem of locating a siding at right angles with the main track may likewise be met by the use of offsets

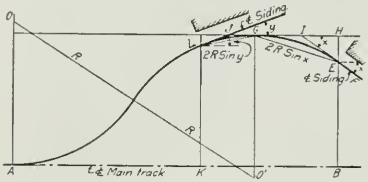

Fig. 3.—A Siding at an Angle with the Tangent Main Track.

and with as great accuracy as the average transit instrument will supply. It is necessary in any event to adjust the detail line of the curve when finally laid, and this can best be done with a string. The formulae for offsets employed in the preceding case will not answer for the circular curve required and the proper formulae for such cases are the following: $p = R - \sqrt{R^2 - l^2}$ and $l = \sqrt{p(2R - p)}$. These symbols signify that for a chosen distance from the point of curve along the tangent, the offset is equal to the radius minus the square root of the difference between the radius squared and the linear distance squared; or, conversely, for a chosen offset from the tangent, the linear distance is equal to the square root of the product of the offset multiplied by the difference between twice the radius and the offset.

This may be used for the offsets from either end to the middle of the curve, for which point it should be noted that the linear distance is equal to the radius divided by the square root of 2, which is 1.414, and the offset is equal to the differnce between the radius and this linear distance.

A test of the correctness of the layout will lie in the fact of the total measured length of the curve agreeing with the length as computed by the simple properties of the circle.

The problem when the line of the siding either converges toward or diverges from the line of the main track may appear to be quite complicated, but when understood becomes really quite simple. The field work necessary to a solution of such a case consists only in measuring the angle of divergence and the offset distance at the point of tangency. The problem then is to determine the position of a tangent parallel with the main track which, for the chosen radius, will make the curve pass through the point desired and be tangent to the line of the siding at that point.

The field books develop with great interest to the mathematically inclined the problem of finding the equal radii for a known position of the line joining the two ends of the reversed curve. But as the effect of such a proposition is to establish a curvature that will generally necessitate the use of special frogs it is clearly not of much use in the solution of the practical track problem.

The angle may be obtained with the tape line by laying down equal distances along the two sides of the angle and measuring the spread at the ends of such distance and by dividing the constant 57.3 by the ratio of these measurements, which it will be noted is the same problem as used in measuring the angle of a frog.

The length of chord subtending a central angle of this computed value may be found with sufficient accuracy by dividing the angle by the degree of curve. The tangent offset for this chord will be obtained from the formula in Example 1, and the linear distance by a solution of the right angled triangle in which the chord is the known hypothenuse and the tangent offset the other known side. The position of the parallel tangent and the linear distance to the point of curve are now known and the solution of the problem becomes simply that of Example 1, except that for the diverging line a portion of the computed curve is imaginary and for the converging line a portion of the computed curve will be duplicated beyond the point of tangency with the imaginary parallel line.

The problem of establishing a connection from a curved main track requires instrumental work in measuring the angle between the siding tangent and the tangent to the main track curve at the point of intersection and of deflecting for the several stations after computing the length of curve between the point of intersection and the p. c. of the siding curve and of the distance on the siding tangent between the main track curve and the p. t. of the siding curve. This distance from the main track curve to a possible point of tangent for the siding curve should be measured as a check on the selection of radius for the siding curve. The choice of curves is limited to those

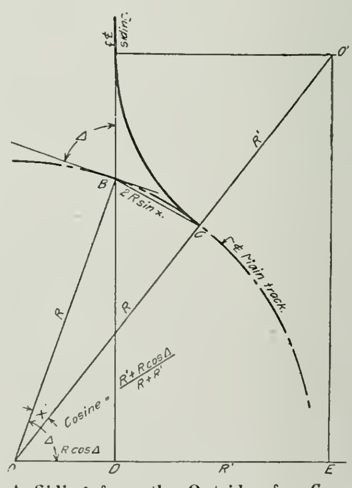

Fig. 4.—A Siding from the Outside of a Curved Main Track.

which will permit the use of a regular number of frog and will thus be the curvature of some regular connection plus or minus the degree of the main track curve, depending upon whether the siding is from the inside or outside of the curve.

There are six cases of this one general problem, of which the two that most commonly occur are given. The other cases include two more from the inside, in both of

N.B.—In Figs 3, 4 and 5, the quantity "2R sin x," should read "2R sin ½x."

which the angle Δ is greater than 90 deg. and R^1 either greater or less than R cos Δ, and two more from the outside in both of which Δ is less than 90 deg. and R^1 either greater or less than R cos Δ. Each case supplies variations which the mathematical skill of the engineer will readily differentiate.

The solution of all is rendered more facile by extending the siding tangent to a normal line which passes through the centre of the main track curve and intersects a line parallel with the siding tangent through the centre of the siding curve. This brings the measured angle Δ, which it will be noticed is included between the radius of the main track curve and the normal to the siding tangent, into direct geometric relation with the two known radii. The solution indicated for the two cases may be applied with apparent modification to all the cases when the angle between the siding tangent and the radii passing through the p. c. of the siding curve may be obtained, as well as the central angle of the siding curve and the distance to the actual p. t. of the siding curve when a test of the correctness of the assumed radius will be had upon comparison with the tentative measured distance.

When it is not necessary to establish the siding curve immediately, the work may be greatly simplified by taking scale measurements from an accurately plotted plan. These will answer every purpose if the original survey was correct and the drawing made to a scale as large as 1 in. to 40 ft., or preferably 1 in. to 32 ft.

The problem of locating a siding on a continuous simple curve which shall pass through two definite points is of very frequent occurrence, as when a property corner must be avoided and farther on a corner of a building cleared. The finite problem is capable only of theoretical solution when the results will be a curve which may or

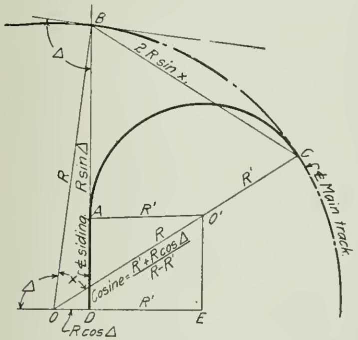

Fig. 5.—A Siding from the Inside of a Curved Main Track.

may not approximate that of some regular connection. But it will generally be possible to change one or both points so that the curve of the nearest regular number of frog may be employed.

The theoretical solution is readily made by means of the geometrical relations indicated in the diagram and furnishes the following formulae by which the radius may first be computed and if this answers the practical requirement, the distance from the point of curve to the foot of the perpendicular through the nearer point.

It will be noted that the formula for obtaining the radius has been reduced with a view of establishing the function R in its simplest form, which will be found to facilitate greatly the detailed solution. Indeed without this simplification the solution is immeasurably tedious.

$$R - \frac{a+b}{2} - \frac{c^2}{2(a-b)} = \frac{c}{a-b}\sqrt{2bR - b^2}$$

$$x = \sqrt{b(2R - b)}$$

The factor preceding the square root sign need only be carried to two decimal places and to the same degree of accuracy when squared. The remaining members may be used throughout of the nearest even whole number.

When the radius found is not of practical application, as when a radius of 375 ft. results, which lies midway between the curve of a No. 6 and a No. 8, No. 7 not being used, the problem becomes one of adjustment within the limits that are possible for changes in the two assumed points. The quarters will seldom be so close that a change of a few feet will not be practicable and in such event the choice will lie between a compounded curve and a special frog.

A solution of the extreme case mentioned will afford some hints that will tend to simplify the solutions of other problems. It should be noted that a radius within 50 ft. will furnish practical results in the use of any particular frog. Thus a radius of 300 ft. will answer for a No. 6 or 450 ft. for a No. 8. But upon the determination of the radius a computation should be made of the distance to the point where the offset distance is equal to the gauge plus ½ in., and this point be used for the point of frog and a proper lead laid off to determine the point of switch, which need not be exactly at the point of curve.

Let $a = 137$, $b = 51$, $c = 100$; then, $R - 152 = 1.16\sqrt{102\,R - 2601}$

Squaring, $R^2 - 304\,R + 23104 = 138\,R - 3511$

$$\begin{array}{l} (138) \qquad\qquad (25737) \\ \hline R^2 - 442\,R + 48841 = 22226 \\ \hline \qquad (\text{diff. } 25737) \end{array}$$

$R - 221 = 149$, or $R = 370$.

Changing to $a = 132$, $b = 56$, $c = 100$, $R - 160 = 1.32\sqrt{112\,R - 3136}$

$$\begin{array}{l} R^2 - 320\,R + 25600 = 196\,R - 5456 \\ (196) \qquad\qquad (40964) \\ \hline R^2 - 516\,R + 66564 = 35508 \\ \hline \qquad (\text{diff. } 40964) \end{array}$$

$R - 258 = 189$, or, $R = 447$ ft., which permits the use of No. 8.

Changing to $a = 144$, $b = 44$, $c = 100$, $R - 144 = \sqrt{88\,R - 1936}$

$$\begin{array}{l} R^2 - 288\,R + 20736 = 88\,R - 1936 \\ (88) \qquad\qquad (14608) \\ \hline R^2 - 376\,R + 35344 = 12672 \\ \hline \qquad (\text{diff. } 14608) \end{array}$$

$R - 188 = 113$, or $R = 301$ ft., which permits the use of No. 6.

Practical Considerations in Siding Layouts.—The feature of clearance in siding layout is a basic one because it concerns not only the switching movements but affects also the question of safety to persons. Some roads prescribe the minimum distance from the track for structures and a few require that this limit shall be followed in the case of movable obstructions. But the addition to this minimum made necessary by the "nosing," overhang or tilt of the cars, which is a variable one, is

not generally stated. Assuming that the widest car which moves in regular traffic is 10 ft. 9 in., a limit of 4 ft. 7 in. from the gauge line of tangents for all obstructions would allow a margin of 1 ft. 7 in. without any correction for accidental unevenness of elevation or for swaying of the car while in motion and with a fair degree of maintenance this would render operation entirely safe.

Car design is such that in a general way the nosing nearly equals the overhang on curves that are without super-elevation. The corrections may be readily computed for cars with 30 ft. truck centres by taking one-fourth the degree of the curve as inches of overhang and assuming that the nosing is no more than that figure and adding or subtracting whatever may be proper for the super-elevation employed. If this is 1½ in. as suggested, the tilt at the eaves of the car would add or subtract 4½ in. from the correction, depending on whether the low or high side were in question. The fact should not be overlooked that at the end of the curve a correction should also be made which is one-half that for the body of the curve. The distance beyond the point of tangency to the point where correction no longer applies is about 18 ft.

The overhead clearance limit is conveniently fixed at 16 ft. above the top of rail which meets the requirements of all present equipment and probably is ample for all future design. As this clearance will not pass a man

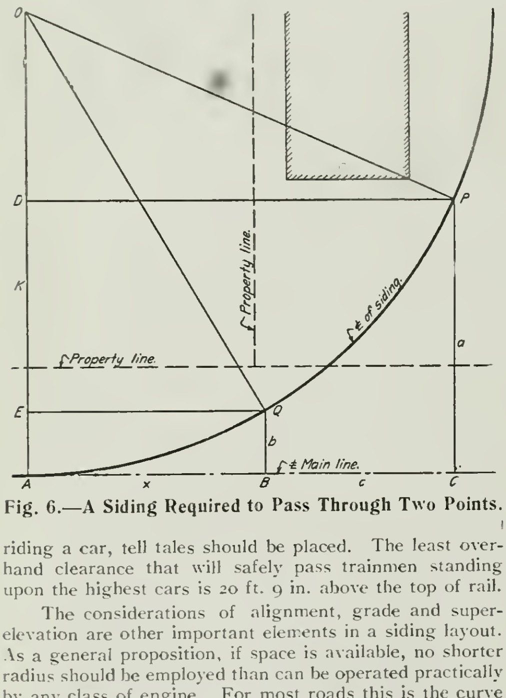

Fig. 6.—A Siding Required to Pass Through Two Points.

riding a car, tell tales should be placed. The least overhand clearance that will safely pass trainmen standing upon the highest cars is 20 ft. 9 in. above the top of rail.

The considerations of alignment, grade and super-elevation are other important elements in a siding layout. As a general proposition, if space is available, no shorter radius should be employed than can be operated practically by any class of engine. For most roads this is the curve of a No. 6 turnout from tangent which is 23 deg. or 250 ft. radius. This requirement is not practical in congested districts and it will often be necessary to modify the curvature to the minimum that a due consideration for safety in coupling cars will permit. This radius has been variously determined, but probably is close to that of a No. 5 turnout from tangent or a 162-ft. radius. Where sharp curvature and maximum gradient are both involved insistence should be had upon the best possible feature for each.

The allowable maximum gradient for siding connections for the best service is 2 ft. in 100 ft. and the maximum for a track upon which cars stand for unloading 1 ft. in 100 ft. It is possible to operate sidings with a gradient as great as 4.7 ft. in 100 ft., but the best drill engines cannot handle more than three loaded cars on such a gradient and the operation is therefore unprofitable. The danger of wrecks from cars running away with the possibility of fouling the main line even when derails are provided renders such a gradient highly objectionable. It is very important that all radical changes of grade in siding connections shall be eased by vertical curves, as the absence of such advantage is a frequent source of accident.

The general feature of gradient concerns the approaches to coal trestles more particularly, and is one where the road must often take a firm stand against the insistence of the applicant for more headroom. The adoption of a limiting gradient by the road many times would supply the means of combating such demands. If greater headroom is desired it can nearly always be had by excavating the site. Any less clear height than 6 ft. 6 in. below the stringers will not permit a horse being driven through and any greater headroom than 14 ft. will break the coal or grind a measurable amount of it into dust with a considerable loss to the dealer.

The question of super-elevation is one concerning which authorities differ. It will be argued that no super-elevation is possible through the connection and therefore none is necessary beyond the connection. But the difference is that the track through the extent of the switch timbers is more rigidly secured in line, surface and gauge, if tie plates be used on the timbers as should be the case, and there is less chance for distortion. It will be found that a super-elevation of 1½ in. for all siding curves is a decided maintenance advantage.

The importance of good line and surface is not fully appreciated. Very many obscure cases of siding derailment wherein the cause given as "truck failing to curve" is really irregular line or uneven elevation. To spend money in siding maintenance is much better than spending it for small wrecks with its annoying interruption to drill work or the possibility of injury to men.

The best maintenance of sidings can only be attained by constant inspection and supervision. The track walker should go over every siding once every day. The foreman should inspect each siding in his territory twice a week. The supervisor should make a careful examination of his sidings and switches once every month and make permanent notes of what he finds. He should also require a report every two weeks from his foremen stating that he has made his inspection and calling attention to any specified repairs that may be necessary requiring material that he lacks. For the best results the foreman should not be overburdened with siding responsibility. Probably 30 switches is the most that one foreman can look after if he has main track duties also.

The first pier of the new Balboa terminal of the Panama Canal is now completed. It is 1,000 feet long and 200 feet wide, the floor being supported on concrete caissons, there being 200 of these sunk to a depth of 61 feet to bed rock. The concrete used in the construction amounted to 27,000 cubic yards. Work was commenced on sinking the caissons in February, 1913, and completed in February, 1914. The superstructure was begun in March, 1914. The new concrete docks when completed will have a water frontage of 5,700 lineal feet.

Editorial

FREE LIME IN CEMENT.

For many years engineers continued in the habit of depending entirely upon the tensile tests of neat cement and 3 : 1 sands, and it was customary for them to ignore entirely the compression tests. It is now definitely known, however, that neat tests have become almost obsolete in European laboratories, the practice being for those interested to confine themselves entirely to the 3 : 1 sands in both compression and tension. But even these tests have been shown to be far from reliable, especially where fine-grain sands are used. In reinforced concrete work the concrete is rarely subjected to tension except in instances of accident in design, and it has been decided that the only use of neat tests is to determine the initial and final set of the cement, of which the initial set should be about one hour. Modern cement is much more finely ground than was at one time the case, and naturally great care should be given to the way in which cement for reinforced concrete work is stored. While previously, in the days of coarse grinding, it was necessary to give plenty of time for aeration in order to render it safe, as it contained a certain proportion of free lime, at the present time, if any of this is present, it is hydrated practically as soon as the concrete is made. If cement is stored in an exposed position it becomes greatly reduced in value, due to hydration, and the only safe method, where it is not required for immediate use, is to stock it in airtight bins. The most accurate test to ascertain the proportion of free lime in cement is still stated to be the "Chatelier," the testing instrument consisting of a section of a small cylindrical tube cut off at a given length, and with a saw cut along its axis. To this two arms are connected, of a given length as compared with its diameter. The cement is gauged with approximately 25 per cent. of water filled into the tube, and stored in cold water for twenty-four hours. After this it is placed in cold water, which is heated to the boiling point, and is then boiled as quickly as possible for six hours. Before this latter process the distance between the pointers is accurately measured, and after the boiling is over the difference in the distance between the arms will show the expansion that has taken place. This difference should not exceed 4 millimètres, and it is said that the concrete made with cement that has passed this test will be absolutely safe in use, and no accident can happen due to the presence of free lime.

CO-OPERATION IN PUBLIC UTILITIES.

This is the time of year when the champions of municipal ownership advance their hobbies into the political arena, and make great endeavors to sway public interest to a general and favorable conclusion with respect to the abstract question. It is interesting to note that, at a large conference of United States mayors held recently in Philadelphia, although there were a number of outcroppings of radicalism, as might have been expected, the dominant opinion was in favor of the privately owned and operated utility, with proper regulation, either state or municipal. Of interest also were the remarks of Mr. A. M. Taylor, director of city transit, Philadelphia, in outlining the city's policy in dealing with public utilities.

"We recognize," said Mr. Taylor, "the great part which the railroads and other public service corporations can take in the development of this city and its industries, but to so take this part they must have credit upon which to raise large sums of money, and they must be assured of an adequate and attractive return thereon and immunity from unwarranted competition or political and public attacks. The capitalists of this country are going to invest their money in communities where capital is justly treated and permitted to earn attractive returns and are not going to invest money in communities where its security is impaired and its productiveness is unduly curtailed by unreasonable legislation, regulation or competition."

One decided advantage of the exercising of the "municipal ownership" hobby at election time lies in the tendency it has to convert antagonistic relationship between public service companies and the public into a relationship of mutual understanding. In the case of street railways, for instance, it should be the purpose of both railway and officials and responsible public officials to place the relations of the companies and the public upon a permanent basis of mutual confidence. It is necessary that the companies and the public understand and trust each other, otherwise the companies will not prosper, the service will be poor, and the public will suffer.

At the winter meeting of the Pennsylvania Street Railway Association the relation between electric railways and the public was discussed by Emory R. Johnson, Professor of Transportation and Commerce, University of Pennsylvania. Prof. Johnson, who is also a member of the noted Public Service Commission of that city, makes the following statements:—

Electric railway and other public service companies can secure the confidence of the public, provided the companies adhere to methods of financiering and management that square with approved moral standards; provided the companies keep the public fully and accurately informed regarding the affairs of the corporations that serve the public; and provided the service rendered is adequate and efficient.

The affairs of public service companies must be matters of public knowledge, and it will be impossible for a company successfully to conceal operations that would not meet with public approval. Electric railway and other public service companies should keep accurate accounts according to uniform methods, and their financial obligations should be so straightforward that the public will be convinced that the companies are not resorting to the speculative methods of financiering which, though prevalent in the past, have now come to be condemned; also the companies should systematically publish information that will help the public to understand and correctly judge the financial and service operations of the companies.

Good service is fundamental and all important. It is essential to the success of the company and is necessary to secure public approval of what the company does. If the public feels that utility companies are straightforward in their financial management and are rendering good services, it will not be opposed to the maintenance of charges that yield adequate profits. The public demand for good service is stronger than for low fares.

The policy of every utility company should be to study the service demands as fully as possible, and the management may wisely study carefully all serious complaints to services. Careful attention to complaints will be helpful to the company as well as gratifying to the public.

Many electric railway companies have been apprehensive because of the increasing degree of public regulation of their finances, services and charges; but I believe there is less apprehension now than there was 10 years ago. Regulation of public service companies in increasing measure by state and municipal authorities has come about naturally and logically. It is necessary for each municipality to have a unified transportation service; and, with but few exceptions, there is now but one street railway company in each city. The requisite unified service is performed by a consolidated company.

Likewise, the larger interests of the people demand that the state shall, by appropriate regulatory, supplement municipal regulation of public utilities. State regulation is necessary, first of all, because the public service company often serves more than one municipal area. The power that regulates must be as extensive as the object regulated; moreover, state regulation is desirable because experience has clearly shown that in the supervision of accounts, finances, services and charges of public service companies there needs to be an executive body whose jurisdiction is state-wide and whose powers are as comprehensive as the tasks to be accomplished. If the regulation of electric railway and other public service companies were left entirely to municipalities, the regulation would be incomplete and would vary greatly as between different localities. Such a condition would be of disadvantage to the companies and not a benefit to the public.

PROTECTING METALS BY CALORIZING.

A NEW process which will lead to economies in various phases of manufacture by preventing metals, especially iron, from burning when subjected to high temperatures for either long or short periods of time, and for one or many heats, is described by data and illustrations in a recent paper by Messrs. H. B. C. Allison and L. A. Hawkins, of the Research Laboratory, General Electric Co. This process, the discoverer of which is reported to be Mr. T. Van Aller, first consisted of heating metals in revolving drums with mixtures containing, among other things, finely divided aluminum, by which a surface alloy containing aluminum is produced. In the case of copper, this alloy is of the nature of an aluminum bronze, but richer in aluminum than the ordinary alloy of that name and more resistant to heat, so that copper thus treated is protected up to the melting period of the alloy from the scaling which occurs when untreated copper is heated above 300 deg. C. The same general result was obtained in the case of iron and steel.

A modification of this process extends its application to pieces which, because of their shape and size, are not adapted for tumbling. It admits of their being calorized by packing them in, or painting them with, a suitable mixture and heating them. There appear to be many places where it is desirable to use iron vessels or apparatus at temperatures above red heat, and at such temperatures, ordinary iron rapidly oxidizes and scales away. After iron is calorized the effect of heating is slight. Instead of burning and the scale falling off, as in the case of untreated iron, practically no effect can be detected after a considerable time—certainly none which injures the surface.

The above facts seem to indicate that this is a simple method for extending the use of iron under oxidizing conditions at high temperatures, and for greatly prolonging the life in those instances where it is now used, but must be renewed at frequent intervals. In the case of small muffles on crucibles, where temperatures are below 1,000 deg. C., this treatment of cheap cast or wrought iron shapes seems very promising. While the life of the coating depends on the temperature at which it is used, as well as on the duration of time taken in its preparation, i.e., the quantity of aluminum which alloys with the surface of the iron, it does not permit of long use at temperatures much in excess of 1,100 deg. C.

Copper parts also, which are exposed to high temperatures, can have their life increased by calorizing. In some cases calorized copper may be used advantageously in place of aluminum bronze. In some cases, also, the life of copper contacts can be increased by calorizing. For instance, a set of railway controller contacts which were calorized showed double the life of the ordinary untreated contacts.

The effect of calorizing is to produce a surface alloy containing aluminum. The thickness of this alloy varies with the length of time to which the piece is subjected to the calorizing process, and the percentage of aluminum varies through the coating being greatest at the surface.

For iron, calorizing is intended only for protection at high temperatures. It does not compete with galvanizing, sherardizing, and other similar processes for protection against oxidation or corrosion at low temperatures. Its usefulness lies within a range of temperature much higher than a galvanized or sherardized coat could stand. For copper, calorizing is effective against corrosion at low temperature as well as against oxidation at high temperature. The upper limit is determined by the melting point of the alloy, which is somewhat lower the heavier the calorizing treatment, since that means an alloy with a higher aluminum content.

The probable explanation of the effect of the aluminum in the surface alloy is that a thin coat of alumina forms which prevents further burning of the metal beneath. It is well known that a pure aluminum wire may be heated in the air to a temperature several hundred degrees above its melting-point, without flowing, when the thin alumina shell which surrounds and supports the molten metal is easily seen.

AT LAST.

The following clipping is from the Kansas City Post, of recent date:—

"An engine that runs itself on its own power, developing energy to operate machinery, has been invented in this city. The inventor has been working for five years on his self-operating engine, and now has it near perfection. A few alterations are to be made. These will increase its efficiency.

"The engine is run by compressed air, making its own pressure as it runs. The exhaust from the cylinders returns through a series of 8-port automatic valves, to a large steel pressure tank. This tank is a double affair, there being a smaller tank within the larger one.

"An air space of 6 in. intervenes between the two tanks. Into the air space the exhaust from the cylinders is forced, the action being such that the nitrogen gases are separated from the oxygen and forming a lighter gas, rises to the top of the tank, at the same time creating a pressure which forces the fresh air down through the inner tank and back into the engine, which is operated by this pressure."

Coast to Coast

Vancouver, B.C.—The large wharf that is being constructed for the Vancouver Island division of the Canadian Northern Pacific Railway will be ready for use early in the new year.

Moose Jaw, Sask.—During the past season 9.85 miles of streets were graded, involving the excavation of 30,680 square yards of material at a cost of $8,530.17, or a rate of 27.8 cents per cubic yard. The city has 36 miles of graded streets.

Moose Jaw, Sask.—The city has 35.66 miles of sanitary sewers, of which 2.33 miles were laid this year. The mileage of water mains is 66.44, of which 2.90 miles were laid this year. The number of fire hydrants on domestic water mains is now 306, of which 22 have been installed during the season.

Galt, Ont.—The Lake Erie and Northern Railway line has been connected up with the C.P.R. line at Main Street. The ballasting of the new road in Galt is now about complete, and work has commenced on the erection of a station on Main Street pond, the filling in of which has been finished.

Victoria, B.C.—The construction of a wharf at Patricia Bay has been commenced by Mr. S. Doe, who has been awarded the contract by the Canadian Northern Pacific Railway Company. The structure will have a width of 64 feet and a length of about 145 feet.

Vancouver, B.C.—The Dominion Board of Railway Commissioners, in session at Vancouver some time ago, cancelled their previous order for viaducts at Pender, Keefer and Harris Streets, over the V., V and E. Railway. A similar viaduct on Hastings Street, ordered at the same time, had not been subjected to delay and is already nearing completion.

Lytton, B.C.—To conclude the section of the C.N.R. between Summit and Kamloops, about 105 miles of track are still to be laid between Albreda and Lytton. Some 65 miles have still to be laid between Port Mann and Kamloops. These are the only remaining sections of the main line. Work is being proceeded with at the rate of 4 miles per day.

Welland, Ont.—The first tubular steel flag-pole made in Canada has recently been erected in Merritt Park. It is 76 ft. long and weighs 2½ tons. It consists of four sections of lap-welded steel pipe. The pole is anchored in a concrete foundation 6 ft. square and 7 ft. in depth. It was manufactured by the Page-Hersey Iron, Tube and Lead Company, Welland.

Toronto, Ont.—Property Commissioner Chisholm recently presented a report showing that the gross value of all civic properties was $35,712,806. The principal items were: City Hall and other public buildings, $6,278,366; Public schools, $6,540,097; parks, $12,352,893; tax sale lands, $1,270,666; High schools, $1,798,922; waterworks, $1,022,795; revenue-producing property, $2,729,191; Hydro properties, exclusive of plant, $269,110.

Saanich, B.C.—On the branch of the Canadian Northern Pacific Railway Company from Victoria to a terminus on the Saanich Peninsula there is a large cut extending for a distance of about 700 ft. and involving the removal of about 50,000 cu. yards of gravel. The excavation is now practically complete, and has been carried out by the firm of McDonald, Nettleton, Bruce, Essbach and Company. Rail-laying on this section has commenced.

Hamilton, Ont.—The Dominion Railway Commission has directed the city's engineering staff, and also the engineering staff of the T., H. and B. Railway, to prepare reports and estimates on the cost of grade separation for submission to it on February 1st, 1915. This is in connection with the old dispute between the city and the company, occasionally referred to in these columns. The Commission has advised the city and railway to get together as much as possible in an attempt to settle their difficulties.

Outremont, Que.—A special feature of the town's new lighting system is that it is entirely served by underground cables, and also that nitrogen-filled tungsten lamps are used exclusively. In both these respects the town deserves publicity, in that it is the first Canadian municipality to inaugurate the above features completely. The town has about 20 miles of lighting system. The installation has cost about $75,000, and has been installed by Town Engineer Duchastel, with the consulting engineering supervision of Mr. L. A. Herdt, of Montreal.

Cobalt, Ont.—The preliminary work in connection with the draining of Cobalt Lake has been completed, and it is at present being lowered, by gravity, to an elevation of 6½ ft. below normal, at which elevation pumping will commence in the spring. The pumping equipment is now in place. The greatest undertaking in connection with this project has been the supply of water for concentrating purposes to the various mills now getting their supply from Cobalt Lake. This has necessitated the daming of a series of lakes and pumping water through an extensive piping system to the mills.

Guelph, Ont.—County Roads Superintendent Young's report outlines the work of two outfits of road machinery continuously employed during the season. Several bridges were built, including the following: Moore's, Pilkington Tp., $845.26; Burnett's, Pilkington Tp., $924.60; Powell's, Peel Tp., $505.26; Parkinson's, Eramosa Tp., $1,037.05; Walker's, Maryboro Tp., $349.11; Scanlon's, Nichol Tp., $458.81; Blyth's, Guelph Tp., $769.02; Moorefield bridge, retaining wall, Maryboro Tp., $2,416.83; Kitley's bridge, Maryboro Tp., $207.51. Considerable drainage, grading and resurfacing on several of the county roads have been proceeded with, the materials used for resurfacing being mainly broken stone and gravel.

Leamington, Ont.—The town has recently awarded the contract for the construction of a drain to consist of 6,500 ft. of open drain, with 6 ft. bottom, 3,371 ft. of 4-ft. concrete tile, 1,456 ft. of 36-inch, 2,935 ft. of 30-inch, 2,956 ft. of 20-inch, and about 2,000 ft. each of 12, 8 and 6-inch, together with 34 catch-basins, 17 manholes, and a small bridge. The contract for the work, which is known as the Selkirk drain, was awarded to the Webster Construction Company, of London, the price being $24,999.50. The contractor intends to manufacture his own concrete tile. Walter Thorold, C.E., consulting engineer, Toronto, was called in to report upon this work some time ago, and it is on his recommendation that reinforced concrete construction was adopted.

Moose Jaw, Sask.—According to a recently issued report of Mr. Geo. D. Mackie, city engineer-commissioner, there are now 40.16 miles of concrete sidewalk in the city, of which 11.25 miles were constructed this year. The Moose Jaw Construction Company had the contract for this season's work, the price being $104,968. The unit price per square foot for the sidewalk was 20.4 cents as against an estimated cost of 25 cents. The total area of the walk laid was 51,000 square feet, curb and gutter 56,000 lineal feet, excavation 20,000 cubic yards, and 7,400 square feet of lane crossings. This contract was stopped in August owing to the outbreak of the European war, and there is left still to be carried out under the contract on the 1914 work about 25,000 square feet of sidewalk.

PERSONAL

ANDREW C. LAWSON, a graduate of the University of Toronto, has been appointed Dean of the School of Mining in the University of California.

PERCY E. JARMAN, who has been acting city engineer of Westmount, Que., since the resignation of Mr. Arch. Curry, about two years ago, has been appointed city engineer.

W. J. FULLER, of the Consumers' Gas Company, Toronto, is conducting a course of ten lessons in illuminating engineering for the benefit of the employees of the company. Courses in other subjects, by other instructors, are being given concurrently throughout the winter.

C. S. J. WILSON, construction engineer with the Dominion Bridge Company, read a paper before the Manitoba Branch of the Canadian Society of Civil Engineers on December 5th, his subject being "Bridge-building in the Rockies, and Engineering Problems Encountered in the Work."

R. G. McCONNELL, who has been acting Deputy Minister of Mines for Canada since the resignation of Mr. R. W. Brock, was appointed Deputy Minister on December 1st. Mr. McConnell graduated from McGill University in 1879, whereupon he joined the staff of the Geological Survey. A great deal of the important exploratory work done by the Survey in Western Canada has been conducted by him.

J. B. CHALLIES and J. T. JOHNSTON, of the Water Power Branch, Department of the Interior, Canada, were in Washington last week by invitation of the United States Secretary of the Interior, Hon. Franklin K. Lane, to explain the water power laws and administrations of Canada to a special committee of the United States Senate, which is drafting a water power bill to cover the administration of water powers under the control of the Federal Government.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

Regular Meeting, December 17th, 1914.

The regular monthly meeting of the Canadian Society of Civil Engineers was held at the headquarters of the Society, 176 Mansfield Street, Montreal, on the evening of the 17th. The first part of the evening was devoted to a discussion of Mr. Surveyor's paper, "Making Our Water-Powers Valuable," a long reference to which was made in our issue of November 26th, 1914. The discussion was participated in by Messrs. Henry Holgate, L. A. Herdt, J. W. Evans, Frederick B. Brown and Ernest Marçeau.

At the conclusion of this discussion Professor Peter Gillespie presented a paper, entitled "Methods of Treatment of Sewage Sludge" (referred to elsewhere in this issue), and gave an illustrated talk on the subject. The greater part of the lantern slides used were made from photographs taken by the author in Europe during the summer of 1913. Prof. Gillespie's address, 1½ hours in length, held his audience in rapt attention. He used no notes, and his familiarity with his subject and his views made it a delightfully smoothly-running and logically-connected discourse.

Mr. Walter J. Francis, chairman of the Meetings Committee, presided at the meeting.

On December 22nd the members of the Ottawa branch of the Canadian Society of Civil Engineers listened to a paper on "Submarines" given by Engineer-Commander P. C. W. Howe, R.C.N.

CALGARY BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

This Branch of the Society held its annual meeting on December 5th, and elected the following officers for the ensuing year:—

Chairman—Mr. F. H. Peters.

Secretary-treasurer—Mr. P. M. Sauder.

Executive Committee—Mr. R. J. Burley, Mr. H. B. Muckleston, Mr. P. J. Jennings.

Auditors—Mr. J. S. Tempest, Mr. F. G. Cross.

The Branch has a number of prominent speakers in view for its winter meetings. It intends to hold a series of luncheons during the season.

At the annual meeting referred to above, Messrs. J. S. Dennis, H. B. Muckleston, F. H. Peters, P. T. Bone, G. Romanes, H. Siddenius and P. M. Sauder were speakers.

VICTORIA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At the annual meeting of the Victoria Branch, held on December 10th, the following officers were elected:—

Chairman—D. O. Lewis.
Vice-Chairman—H. W. E. Canavan.
Treasurer—Frank C. Green.
Secretary—R. W. McIntyre.
Executive—A. W. R. Wilby, A. E. Foreman.
Auditors—E. H. Harrison, H. A. Icke.

In his retiring address, Mr. F. C. Gamble, who has been chairman for the past two years, made the following remarks:—

"To successfully accomplish the advancement of our profession to the position it should occupy, personal aim should be set aside and members should work together unselfishly as a determined body of men, whose sole purpose is to raise the profession of civil engineering to the highest plane of efficiency and influence. By following along the suggestions implied in these remarks we shall soon command a greater confidence and more of the respect of the public. The effect of your efforts may not be immediate nor of direct personal advantage, but indirectly every member will be benefited by the growing influence of our society.

"Each member of this branch should realize his individual responsibility and should not shirk his duty.

"In one direction our activity has not been as great as could be desired, and that is with regard to the preparation and the reading of papers at our monthly meetings. There has been a sad dearth of these. We have men amongst us who can write with ability most interestingly and instructively on subjects they are most familiar with, and I beg of these not to postpone their duty in this respect indefinitely."

On December 10th and 11th the general meeting of the Victoria and Vancouver branches was held. Among the papers presented was that of Mr. J. S. MacLachlan, Dominion Government Engineer, on harbor work at Victoria, who read a paper on "Harbors" and an interesting discussion followed. Mr. G. R. G. Conway, Chief Engineer of the British Columbia Electric Railway Company, and chairman of the Vancouver Branch of the Society, also read a very valuable paper, entitled "Legislation and the Engineering Profession."

The following were appointed to the board of directors of the Ottawa Light, Heat and Power Company at its annual meeting, held last week: Col. D. R. Street, present secretary-treasurer of the company, and Mr. F. W. Fee assistant secretary-treasurer. These vacancies were caused by the deaths of Mr. John Manuel and Mr. Honore Robillard.

Volume 27. Toronto, December 31, 1914

Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

PROGRESS ON THE NEW QUEBEC BRIDGE

SUPERSTRUCTURE ERECTION REVIEWED TO DATE—PROGRAM OF ERECTION—OFFSETTING DIFFICULTIES IN PIN CONNECTIONS ARISING OUT OF ALLOWANCES FOR DEFORMATION OF MEMBERS UNDER FULL LOAD.

By H. P. BORDEN,
Assistant to Chief Engineer.

WITH the close of the present season considerable progress is to be noted towards the erection of the new Quebec Bridge. During the summer of 1913 the approach spans on the north shore from the abutment to the anchor pier were fully erected. These spans were erected by derrick cars on heavy wooden and steel falsework. As these spans would have to carry the 1,000-ton erection traveler, and as the concentrated wheel loads from this traveler were considerably greater than the live loads for which the spans were designed, this falsework was made sufficiently strong to take care of these reactions.

During the winter of 1914 the traveler was erected on the shore, just north of the abutment and it was ready to move out early in May. This traveler was carried on two double lines of tracks, spaced 54 ft. centre to centre. The two inner rails were carried on the top flanges of the outside bridge track girders, the outer rails being carried on special erection girders resting on the falsework and thoroughly braced to the track girders themselves. The traveler was moved out over the approach spans to the anchor pier on May 18th, and proceeded to erect the inside falsework carrying the floor of the anchor arm on which the traveler runs.

Fig. 1.—View Showing North Anchor Arm when Work Closed Down at the End of the Season.

The main floor beams of this floor were supported on special erection girders supported by this falsework and were located in approximately their correct positions. The main track girders, sub-floor beams and stringers were then erected in place and special girders erected outside the track stringers for the erection traveler.

When this falsework had been completed out to the north main pier the main shoes were erected, and the bases for these shoes were accurately placed and the entire shoe erected. An elaborate series of triangulations and measurements, extending over several months, were made to locate the longitudinal and transverse centre lines of these shoes. Once the bases had been placed in their proper position the rest of the shoe went forward rapidly, and a start on the erection of the bottom chords was made.

According to the program of erection, it was proposed to lay the bottom chords complete with their lateral bracing from the main shoe to the anchor pier, the main traveler moving back as the work progressed. When this had been done the traveler moved ahead again to the main pier and started the erection of the web members up to their middle intersection above the floor. This was carried back to the north anchor pier, after which the erection of the upper half of the web members in the top chord was effected, the traveler moving forward as the work progressed.

Work stopped for the season with the anchor pier completely erected with the exception of two upper panels near the main pier.

Owing to the deformation of all members under full load, it has been necessary to manufacture the compression members slightly longer and the tension members slightly shorter than their actual geometric length. On account of this fact there would naturally be difficulties in making the pin connections between the various members of the anchor arm in view of the fact that all these members are erected on falsework and consequently under no load except from their own weight. To offset this difficulty, the bottom chord was given a camber which would correspond to the deformations indicated by the Williot's or deformation diagram. In other words, after the bottom chord had been entirely riveted up from end to end, it was lowered a certain amount at each panel point by means of jacks at the foot of the steel falsework to correspond to this deformation. The final displacement, including deformation of falsework posts, amounted to zero at the main shoe, seven inches at the middle point, and five inches at the north anchor pier, varying practically uniformly between these points.

Owing to the length of this bottom chord, it was able to obtain this deformation without any difficulty.

To offset the effect of deformation of the web members from their own weight, and to enable pins to be driven without any difficulty, elongated holes were bored in the upper end of the upper tension diagonals and in all the eyebars in the top chord. The holes in the diagonals were elongated 2 inches and each eyebar ½ inch at each end, the elongation being made in the side of the hole nearest the centre of the member. By this means it was possible to drive these pins without any difficulty, the play in the holes being taken up as the cantilever arm is erected and stresses applied to the members of the anchor arm.

The driving of pins was materially facilitated by the fact that these pins are in duplicate, each pin going through two webs only of the 4-web members. This also applies to the top chords. In designing the driving rams for these pins it was estimated that heavy rams, weighing in the neighborhood of two or three tons, would be required. It was found in actual practice, however, that these were not necessary, and after the first one or two pins had been driven a steel rail 10 feet long, weighing 80 lbs. per yard, was used and pins in practically every case were driven home in from one to two minutes.

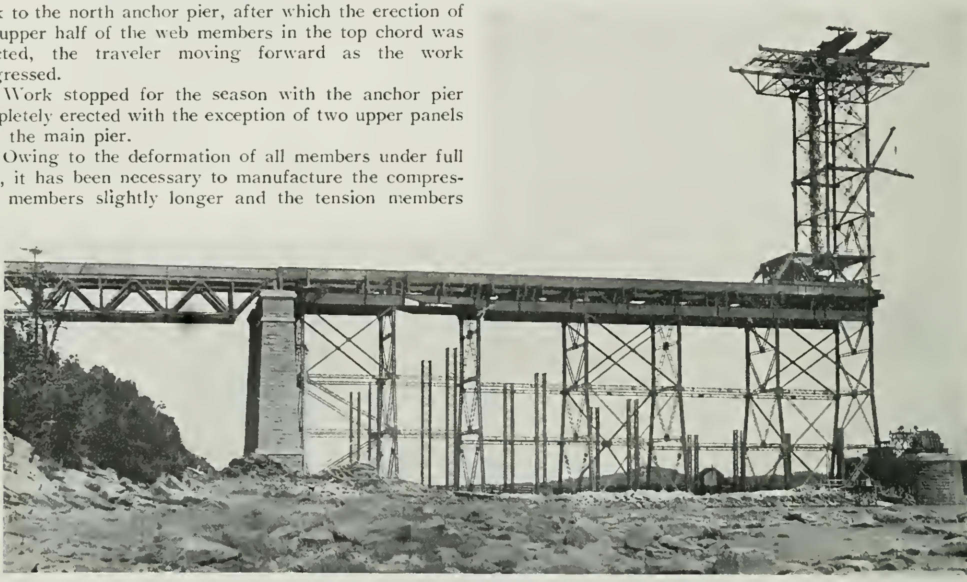

Fig. 2.—Falsework and Floor Erected, and a Start Being Made on the Erection of the Main Shoes.

The maximum clearance allowed in all pin holes is 1/32 inch + 1/100 inch.

The amount of steel erected during the season just passed is about 15,000 tons, and this was practically erected in four months, from August 1st to December 1st.

A duplicate traveler is now being erected on the south side of the river and will be in commission the first thing in the spring. If the work is carried on according to programme, it is expected that the remainder of the anchor arm and the whole of the north cantilever arm as well as the south anchor arm, should be erected next season.

The St. Lawrence Bridge Company, Montreal, are the contractors for the superstructure. The work is being carried out under the supervision of the Board of Engineers, Quebec Bridge, composed of Mr. C. N. Monsarrat (Chairman and Chief Engineer), Mr. Ralph Modjeski and Mr. C. C. Schneider.

ECONOMIC FEATURES OF THE ROGER'S PASS TUNNEL.

FROM time to time articles and notes of engineering interest have appeared in this journal on the five-mile, double-track tunnel which Messrs. Foley Bros., Welch and Stewart are driving through the Selkirk Range, in the vicinity of Roger's Pass, for the Canadian Pacific Railway Company. For a description of the engineering features of the undertaking the reader is referred to *The Canadian Engineer* for April 23, 1914, page 621. Maps and profiles of the old and proposed lines are illustrated therein to good advantage, and a reference to them will be of assistance in the following portrayal of the problem in economics which the revision of railway location has presented.

The following abstract from a paper by J. G. Sullivan, C.E., chief engineer of the western lines of the C.P.R., presents the factors involved in a study of the cost of operation via the present and proposed routes. We are indebted to the "Cornell Civil Engineer" for the information. (Mr. Sullivan is a graduate of Cornell University, Class '88.)

The data to be taken into account is as follows: Present location, total distance 23.1 miles, revised location 18.68 miles; grades consist, on the present location of 16.65 miles up hill for westbound traffic on maximum grade of 2.2%, 6.45 miles down grade same maximum with a total rise of 1,726 ft. and a drop of 692.1 ft. with 1,860 degrees of curvature on the up hill and 1,288 degrees on the down hill portion of the line. The revised location consists of 16.77 miles up hill with about 5 miles of 2.2% pusher grade, the balance 1% and a down hill run of 1.91 miles with a maximum 2.2% grade; a total rise of 1,178.2 ft. and a drop of 144.3 ft., with 635 degrees of curvature on the up hill grade and 66 degrees on the down hill. The average traffic for the years 1912 and 1913, which is made the basis of calculations, was 1,342½ passenger trains in each direction; the average weight of the passenger trains, exclusive of locomotives, was 443 tons; 980 of the passenger trains required pusher engines; the weight of the passenger and pusher engines for passenger trains was 175 tons each; there were 173½ freight trains in each direction per year; the average weight of the freight trains eastbound, exclusive of locomotives, was 950 tons; the average weight of freight trains westbound was 898 tons; all freight trains had to be pushed in both directions; weight of freight locomotives and pushers, 181 tons each. The tonnage eastbound and westbound was as follows:—

Eastbound.

1,342½	trains @ 443 tons each	594,727.5	tons
2,322	locomotives @ 175 tons each..	406,350.0	"
1,738½	freight trains @ 950 tons each	1,651,575.0	"
3,477	locomotives @ 181 tons each ..	629,237.0	"
	Total	3,281,889.5	tons

Westbound.

1,342½	trains @ 443 tons each	594,727.5	tons
2,322	locomotives @ 175 tons each..	406,350.0	"
1,738½	freight trains @ 898 tons each	1,561,173.0	"
3,477	locomotives @ 181 tons each ..	629,237.0	"
	Total	3,191,487.5	tons

Comparison of Comparable Factors Affecting the Cost of Operating Over Roger's Pass, via Present Line and via Tunnel Line, Now Under Construction, Average Traffic for the Years 1912 and 1913.

E. B. tonnage per year, including weight of engines, 3,281,890 tons.

Resistance to overcome, on present line.

Actual rise, 692.1 ft.	692.1 ft.	
Curve resistance, 1,288° × .04′	51.5 ft.	
Friction resistance, 6.45 mls. × 15′..	96.7 ft.	
Total		840.3 ft.

Resistance to overcome, tunnel line.

Actual rise, 144.3 ft.	144.3 ft.	
Curve resistance, 66° × .04′	2.6 ft.	
Friction resistance, 1.91 mls. × 15′	28.6 ft.	
Total		175.5 ft.
Difference		664.8 ft.

3,281,890 tons × 664.8 ft. equals 2,181,800,472 foot tons.

W. B. tonnage per year, including weight of engines, 3,191,488 tons.

Resistance to overcome, present line.

Actual rise, 1,726 ft.	1,726.0 ft.	
Curve resistance, 1,860° × .04′ ...	74.4 ft.	
Friction resistance, 16.65 mls. × 15′	249.7 ft.	
Total		2,050.1 ft.

Resistance to overcome, tunnel line.

Actual rise, 1,178.2 ft.	1,178.2 ft.	
Curve resistance, 635° × .04′	25.4 ft.	
Friction resistance, 16.77 mls. × 15′	251.5 ft.	
Total		1,455.1 ft.
Difference		595.0 ft.

3,191,488 tons × 595 ft. equals 1,898,935,360 foot tons.

Total work done (extra)	2,181,800,472 foot tons
	1,898,935,360 foot tons.
Total	4,080,735,832 foot tons.

1,000 foot tons equals approximately 1 horse-power hour. Assuming that 5 pounds of coal is consumed in doing one horse-power hour's work and that coal on locomotive costs $4.60 per ton, the saving in fuel will amount to:

$$\frac{4{,}080{,}736 \times 5 \text{ lbs.} \times \$4.60}{2{,}000 \text{ lbs. (one ton)}} = \ldots\ldots \$46{,}928.46$$

Extra Wages, Train and Engine Crews.

Present line.

6,162 trains for 23.1 miles, 142,342.2 train miles.
5,437 push. engs. for 23.1 mls., 125,594.7 push. eng. mls.

Tunnel line.

6,162 trains for 18.68 miles 115,106.2 train miles.
5,437 push. engs. for 13 mls., 70,681.0 push. eng. mls.

Amount saved { 27,236.0 train miles.
54,913.7 pusher engine miles.

27,236 train miles at 22 cents .... $	5,991.92
54,913.7 pusher miles at 25 cents	13,728.40
NOTE—25 cents to cover engine crew wages, cost of repairs to pusher locomotives and extra cost of maintenance account of running pushers.	
Extra cost maintenance of way, 4.42 miles at $200 plus 27,236 train miles at 20 cents	6,331.20
Extra cost, maintenance of way, account of extra number of degrees of curvature, assuming that 400° of curvature per mile would increase rate at 20 cents per train mile for maintenance by 30%.	
6,162 trains × 2,447° × 1/40 cents	3,769.60
Special maintenance, account 4½ miles snow sheds	85,000.00
Extra cost, maintenance of equipment 27,236 train miles at 21 cents	5,719.56
Extra cost maintenance of equipment, account of extra number of degrees of curvature, assuming that 400° of curvature per mile would increase rate of 21 cents per train mile by 40%.	
6,162 trains × 2,447° × 21/1,000 cents	3,166.47
Total annual saving in cost of operation.	$170,635.61

The rate at which traffic has been increasing would indicate that shortly after the work of constructing the tunnel was completed the traffic would have doubled. In this case, if no further economics were made in methods of operating this section of track, the annual saving on account of operating over tunnel line would be,

$85,635.61 × 2 plus $85,000 = $356,271.22

In arriving at the above figures no account is taken of whether line was single or double track and for comparative figures it was assumed that methods of operation would be the same. Now, as a matter of fact, the present single track line with double the present traffic would make the business too congested for economical single track operation. Therefore, it was apparent that it was time to study the question of double tracking the present line or seeking a new line for double track. It was decided to double track on the five-mile tunnel location with grades as noted above. Now, to operate successfully a five-mile tunnel we will require the installation of an electric plant and the purchase of electric locomotives. All the details of the proposed electrification have not as yet been worked out, but even if they were, the reader is not interested in the details of cost. He can see at once that the problem was to find out if the cost of operating and maintaining the tunnel line, taking into account the extra costs of operating on account of having a short section of electric operation and extra cost of maintaining tracks in the tunnel, plus the interest on the cost of building the new double track line including the cost of electrifying the tunnel would be less than the cost of operating and maintaining a double track line on the present location plus the interest on the cost of building the second track. The figures would not have been very decisive one way or the other were it not for the fact that there is now 4½ miles of wooden snow sheds on the present location which will be all done away with on the new location. The maintenance and cost of renewals of these sheds cost between $85,000 and $100,000 per year. To maintain and renew a double track wooden shed would probably cost at least 50% more than the above, so that with a saving of about $125,000 per year in maintenance and renewals of snow sheds and a calculated saving in operation and maintenance of $171,271.22 on a traffic that surely will be reached in the near future, there was no doubt as to the proper course to pursue.

As to the details of figuring economics of railway location, the writer is well aware that it is impossible to devise any method that will show absolutely that saving in cost of operating one line over another, but he believes that the method herein followed, namely, that of comparing cost of fuel on the basis of work done rather than on a train-mile or any other unit is much more logical and will give more reliable results than other methods that have been followed. The train-mile is possibly the best unit for comparison in cost of wages and for cost of maintenance of equipment. In figuring maintenance of way a fixed sum should be taken plus a rate per daily train rather than a fixed rate alone per train-mile, for the reason that a certain amount of expense must be incurred regardless of whether trains are run or not. The fixed sum of $200 per mile taken in this problem is probably about one-half the actual sum that would be assumed if the entire cost of maintenance was to be included in this fixed sum per mile plus the rate per train mile for the reason that cost of maintenance of terminals and other items are not affected by the details of location between fixed terminals.

Frictional resistance, normal conditions, warm weather, modern freight equipment, speed between 7 and 35 miles an hour,

$R = 2.2\,T + 121.6\,C.$

R = total resistance on level tangent.

T = total weight cars and contents in tons.

C = total number of cars in train.

This amounts to 4 lbs. per ton to 8 lbs. per ton, depending on whether cars are fully loaded or empty. This is equivalent to a rise of from 10 ft. to 20 ft. per mile. For mixed traffic a conservative estimate is train resistance equals rise of 15 ft. per mile.

It may appear that the rate of 25 cts. per actual pusher-mile covering the cost of repairs and engine crew wages and extra cost of maintenance is too high, but as a matter of fact it is very conservative for the repairs, maintenance and renewals of the locomotives alone will run somewhere between 7 cts. and 10 cts. per mile and we have had cases where the engine crew wages alone averaged 25 cts. per mile for the actual mileage run, on account of delays to the pusher.

The progress made since the commencement of operations was reviewed in an article in *The Canadian Engineer* for October 1st, 1914. A few weeks ago reference was made to the establishment by the contractors of a new record for hard rock tunneling of 817 feet in 30 days, with a maximum footage of 37 feet in a single day.

C.P.R. FREIGHT TERMINAL AT QUEBEC.

The Canadian Pacific Railway has under construction at Quebec a large freight terminal, consisting of an inbound shed 50 ft. x 600 ft.; an outbound shed, 30 ft. x 300 ft., with a transfer platform, 300 ft. in length between. The W. S. Downing-Cook Co. have the contract, and Mr. S. G. Newton is their superintendent on the work. Steel is furnished by the Dominion Bridge Co. Terminals were designed by the building and construction department of the C.P.R., of which department Mr. D. H. Mapes is superintendent.

The foundation and floors of the two sheds are of reinforced concrete, supported on Raymond concrete piles.

IMPROVEMENTS TO NAVIGATION IN AND AROUND MONTREAL HARBOR.

THE season's grain export from the Port of Montreal has been stated to be the greatest in history. The total amount of grain passing through the two elevators of the Harbor Commission, the Grand Trunk elevator and the floating elevator, was 73,628,132 bushels, not including a million and a half bushels of grain which had been bagged and shipped direct, or over 10,000,000 bushels handled by the elevators for local consumption.

During the year the Repentigny channel from Isle St. Therese to Lanoraie has been finished, completely buoyed, and opened to navigation for boats drawing less than 14 feet. Later it will be extended through the Sorel Islands by way of the Grand Channel to Lake St. Peter. This dredging is now nearly completed and the necessary lights will be placed in position next spring. As the result of dredging all season in Lake St. Peter, there is now a 35-foot channel for almost the entire length of the lake. Elevator dredges at St. Anne, Sorel, St. Tours, The Traverse, Varennes and Point aux Trembles, are doing the same work. In Montreal Harbor they are widening the ship channel.

Four elevator dredges, a stone cutter and two stone lifters have been removing rock in the Cap a la Roche district to make a channel with a minimum depth at low water of 30 feet and a width of from 450 feet in the straight parts to 600 feet at the curves. New lighthouses will be erected in this district next year to mark out the new lines.

In the north channel below Quebec dredging has gone ahead for a channel 1,000 feet wide with a minimum depth at low tide of 30 feet, as far east as the foot of the Island of Orleans. Two dredges have worked at it this season, and the Dominion Government has awarded the contract for a seagoing hopper elevator dredge to the Canadian Vickers Company. This will hasten the work, but with the rocky bottom it will probably take nearly five years to finish it.

About $2,000,000 has been expended by the Harbor Commission this year in dredging, renovating piers and wharves, building new sheds and wharves, and other work incident to the five-year programme of development undertaken by them at a total cost of $15,000,000. All this work has been under the direction of Mr. W. G. Ross.

The main dredging in the harbor was south of St. Helen's Island to a depth of 20 feet. The renovation of Victoria Pier and the old low wharves east of it has been continued with the ultimate object of completing 2,700 feet of new high level and 4,800 feet of low level wharves. This will provide new berths for small river boats opposite Bonsecours Market, and for ocean steamers just below shed sixteen and in the neighborhood of the two new steel and concrete sheds, which have just been completed, at a cost of about $400,000. Similar sheds will be built parallel to the current on the new Victoria Pier where a stretch of 1,800 feet of dock is completed.

The $15,000,000 programme for five years includes a new warehousing system, the electrification of the railway system and the extension of the tracks from Racine Pier to Point aux Trembles, and ultimately to Bout de L'Isle. The Canada Cement and the Armstrong-Whitworth companies have had wharves built this year.

In connection with the Lachine Canal, $500,000 has been spent this year to eliminate the curve, which proved dangerous to navigation at Cote St. Paul, and the new power house nearby will be completed next year. A larger intake at Cote St. Paul was finished this season. Above Cote St. Paul, a mile of new cement wharf has been built.

Adjoining the easterly limits of the harbor are the newly completed works of Canadian Vickers, Limited, where $3,000,000 worth of construction has been completed during the year in addition to the floating dry dock valued at $1,750,000. These works consist of an iron-workers' shed, constructed in 3 bays, one being 300 feet long and the others 500 feet each, the width being 50 feet; mechanics' shop, 100 ft. x 50 ft.; joiners' shop, 120 ft. x 100 ft., 2 stories; ship building berth, 500 ft. x 132 ft.; power house, gas plant, etc., in addition to a 1,000-ft. x 500-ft. filling out basin with reinforced concrete retaining walls. Between 4 and 5 miles of service tracks give connections with the C.P.R., C.N.R. and G.T.R. In this plant some 600 men are now busy, most of them on a million-dollar icebreaker for use in the St. Lawrence River by the Dominion Government, the second largest icebreaker in the world. It is hoped that the launching will take place next June. Next month they will start a new $835,000 bucket dredge, ordered by the Dominion Government. It is to be delivered early in 1916. During part of the season as many as 1,500 men were engaged. Twenty-seven vessels have been repaired in the dock during the summer.

A NEW SWISS TUNNEL.

The tunneling problems incident to the projection of railways in Switzerland and Northern Italy present features of considerable interest to engineers on this continent. The fact that several tunnels have recently been pierced has received comparatively small publicity owing to the prominence of military affairs in Europe. The Hauenstein base tunnel is 5 miles 94 yards in length. The Munster-Grenchenberg tunnel is slightly longer, being 5⅜ miles in length. The latter was commenced in November, 1911, and is being constructed by the Bernese Alpine Railway Co., the builders of the electrically equipped Lötschberg tunnel. (See *The Canadian Engineer*, October 30, 1913.)

The Munster-Grenchenberg tunnel is, according to "The Engineer" (London), costing about $5,000,000. It is being laid with a single track only, and will have steam traction. It will be used under the direction of the Swiss Federal Railways. The new tunnel pierces the Jura Range, the height of mountain overhead having a maximum of 2,624 ft. The chief difficulties encountered in its construction appear to have been due to subterraneous springs and water pockets. As in the Simplon tunnel (see *The Canadian Engineer*, May 14th, 1914) a difficulty arose, prior to piercing, owing to water having accumulated in one shaft, and great care had to be exercised not to allow it to flood the other shaft.

The tunneling has been done for the most part with Meyer hand-boring machines.

The period allowed for building is 3½ years. The masonry lining of the tunnel is already well advanced, and it is confidently expected that it will be entirely finished within the specified time.

A list of European tunnels with their locations, lengths, summit levels and dates of operation appeared i this journal for March 26th, 1914, page 508.

The Canadian members of the International Waterways Commission were in conference in Washington last week It is stated that the subject under discussion was the matter of polution of boundary waters.

DESIGN, MAINTENANCE AND OPERATION OF PLANTS FOR TREATMENT OF SEWAGE.

At the recent convention of the American Public Health Association, held in Jacksonville, Fla., the question of sewage treatment received worthy consideration in the valuable progress reports presented by several committees of the association. One meriting careful perusal had to do with the design and operation of treatment works, and was submitted by the committee on sewerage and sewage disposal, consisting of Messrs. Geo. S. Webster, chairman; Frank A. Barbour, Geo. A. Johnson, Langdon Pearse, and F. Herbert Snow. A portion of the report is as follows:—

All disposal works should be recognized as machines which require intelligent supervision and which, if properly designed and maintained, can be made to produce just that quality of effluent which the diluting capacity of the local stream will render satisfactory. In this way greater general progress in the betterment of stream conditions will result.

It will frequently happen that, in small streams, the dry-weather flow can, with profit, be increased by the intelligent use of stored upstream water, and the discharge of a partly treated sewage thus made possible at all seasons.

Where the two-story type of tank is adopted care must be exercised that the tanks are not made too large, as under such circumstances they are liable to fail of their purpose by reason of the sewage in the settling chamber becoming septicized and creating nuisance.

Patented Processes.—Town authorities should not deal with the proprietors of any patented processes or devices for sewage treatment without the assistance of some competent advising engineer.

The treatment of sewage has always seemed to be a particularly fertile ground for the exploitation of patented methods, from the early days of the many processes of chemical precipitation to the present-day electrolytic treatment; many of these schemes, while apparently successful in the experimental plants, are entirely infeasible on a practical scale. There is danger in deducing results from small test apparatus without scientific study by a qualified expert; often the cost of such treatments, when undertaken practically, is prohibitive. The proprietor of a process who is looking for a contract will give a bond and make various propositions which appeal to the people of a town and in this manner lead them to favor the acceptance of such propositions. Many costly mistakes have been foisted on communities in this way.

Processes of Treatment.—Sedimentation and Sludge Digestion.—Usually the first process of treatment is the removal of the solid matters which have been maintained in suspension by the velocity of flow in the sewer. In the past, when the solids were allowed to settle in tanks in which the sewage flowed over and in contact with the putrescent deposits in the bottom, odors resulted. Also, when the deposit from such tanks, called sludge, was placed upon the ground or upon drying beds, the foul emanations added to the nuisance. But within recent years, two-story tanks have been devised and are in successful operation whereby the sewage is settled for a short period of time in the upper story and the sludge allowed to remain in the lower compartment of the tank sufficiently long for the decomposable matters to digest, and the settling sewage is kept from coming in direct contact with the digesting sludge.

Such tanks will discharge an effluent practically free of settleable matter in nearly as fresh a condition as when received. The gases evolved during digestion of the sludge away from contact with the sewage are principally methane or marsh gas and carbon dioxide, both of which are inodorous. Sludge withdrawn from such tanks after digestion is inoffensive, dries quickly and may be used for filling low land or for agricultural purposes with no danger of nuisance.

Oxidation.—If the conditions require more refined treatment than sedimentation, it becomes necessary to adopt processes for oxidation. This may be accomplished by means of intermittent sand filters, contact beds or sprinkling filters, the choice of which is largely dependent on the availability of different construction materials and the size of plant to be installed. Intermittent sand filters are only economical where large areas of sandy soil are available. The sprinkling filter, on the score of economy and on account of the maximum efficiency secured on a minimum area of land, is generally given preference; yet under certain conditions contact beds are justified.

The present-day tendency is to adopt processes which will maintain, as far as possible, aërobic conditions in the liquid at all stages through the plant; the maintenance of such aërobic conditions is the primary consideration in avoiding nuisance.

Disinfection.—As the purpose of disinfection is the destruction of pathogenic bacteria, in order to provide a double safeguard against water-borne diseases, it can be generally said that disinfection of sewage is an unnecessary refinement, unless the effluent of the sewage-treatment works is discharged into a water course adjacent to and above the intake of a water-purification plant, and even in such a case the responsibility of protecting the public health should rest upon the purification of the water.

It is not practical to disinfect crude sewage containing particles of organic matter of appreciable size, as with the usual period of contact it is impossible for the disinfectant to penetrate the solids.

Odors and Their Avoidance.—The amount of odors depends largely on the freshness of the sewage and the method of treating and handling the sludge. The freshness of the sewage depends largely on time of travel and the design of the collecting system, on the adaptation of size to discharge, the provision for self-cleansing velocities and on the ventilation of the sewers so as to provide as much natural aëration to the liquid as possible. If the sewage is fresh or if, in other words, it contains dissolved oxygen, there will not be serious odors from the application or treatment of the liquid portion, provided the plant is maintained with no lodgment of sewage in pools or overloading of the surface of the filters.

There is a potential cause of odors in the sludge. But by the use of the more modern type of tanks, with thorough digestion of the decomposing solids and discharges on properly prepared sludge-drying beds, under favorable weather conditions, no odor of serious moment, noticeable more than a few hundred feet, should ever occur. Odors can be largely eliminated by good design, but their occurrence depends more particularly on proper supervision of the plant.

By the use of the two-story sedimentation tanks, which provide for the digestion of sludge, and by care in the management of the works, plants are operated in Europe and in this country where no odors are noticeable either from the sewage or from the sludge during drying.

In plants where other methods of treatment are adopted it is probable that odor will be produced. It has been estimated that at such a plant capable of treating the sewage of 50,000 people, with good management no odors should ever be apparent beyond 1,000 to 1,200 ft. from the works, even when sludge is being discharged upon the drying beds or in the spring when the filters are in bad condition, due to the past winter interfering with work being done on them.

With smaller plants this distance should be less, and with larger plants possibly more. By diffusion, of course, the odor becomes more faint as the above-named distances are reached, and beyond these distances no odor should be noticeable. What might be termed odors, strong enough to be disturbingly disagreeable to a person whose nasal sensitiveness is not affected by his knowledge of the source of the odor, should, perhaps, never be found at a distance more than one-third of those mentioned. It should, however, be noted that an odor from a sewage plant which, if from a farm would never be noticed or would be accepted as simply natural and reasonable, will generally develop complaints of nuisance. Sentiment, regardless of facts, frequently blames on an inoffensive sewage-disposal plant bad odors from other sources. In short, sewage-treatment works should be as isolated as is economically possible.

For the avoidance of odors, the fundamental considerations are the delivery of the sewage as fresh as possible at the plant, the application of the liquid portion to filters before the sewage has become stale, and the proper treatment of the sludge so as to render it comparatively odorless and easily handled.

Sewage-Works' Attractiveness. — Disposal plants should be made attractive by planting and parking, and no money can be better spent than this. The trees to some degree prevent the spreading of the odors, and in the planting of trees and shrubs the direction of the prevailing wind should be taken into account.

Local authorities, when they first take up sewage-treatment for consideration, frequently look upon the plant as a dump for municipal waste, and it never occurs to them that it is good policy to spend money to make the works so attractive that people will voluntarily make it the objective point of their Sunday afternoon strolls.

Such beautification and the proper maintenance of the appearance of the plant are the surest and best means of preventing complaints of odors or nuisance; this because of the psychological effect on those living near the plant, and also on the attendants, who unconsciously adopt a higher standard of cleanliness and care of the works.

Another notable report was that presented by the committee on sewage works operation and analytical methods. This committee consisted of Messrs. W. L. Stevenson, chairman; C. B. Hoover, H. C. McRae, Langdon Pearse, Geo. C. Whipple, and F. E. Daniels. One interesting feature of the report is its recommendation to the laboratory section of the association that it take up for consideration the improvement of the test for suspended matter in sewage. In respect to this test, to which it refers as a test for not only the amount but also the condition and physical characteristics of this suspended matter, the committee states:—

Suspended matter was first determined by the difference in the weight of the residue upon evaporation of a portion of the sample filtered through paper and another unfiltered. At the present time, the Gooch Crucible is generally used to obtain the weight direct. In both procedures the organic portion of the suspended matter was estimated by determining the loss of weight upon ignition. The Royal Commission on Sewage Disposal attempted to devise a method for determining the amount of suspended matter by means of the centrifuge. In the works of the Emschergenossenschaft a simple field method is in use for determining the bulk of the settleable matter by subsidence in graduated conical glasses.

None of these methods, however, furnish information concerning the size, physical condition or other characteristics so essential to know in the preliminary treatment of sewage. One of the reasons for this is the small size of the sample examined and the difficulties of obtaining a representative portion for analysis; for the inclusion or exclusion of a large size piece of suspended matter in a small sized sample will cause large variation in the result obtained.

The efficiency of all preliminary processes depends upon the removal of the settleable solids and, therefore, a test to measure them is of great importance.

It is, therefore, recommended that in sewage works operation some procedure for the determination of suspended matter be used and that analysts be urged to devise a technique to supply the information required.

Another recommendation of the committee urged that during the coming year analysts direct their attention to the simplification and standardization of the test for avidity for oxygen, or, in other words, a test for measuring by incubation the avidity of the sample of sewage or effluent for dissolved oxygen or its equivalent. The Royal Commission on Sewage Disposal developed a technique for such a test. Another method was developed by Mr. C. B. Hoover and is in use at the sewage treatment works at Columbus, Ohio, and still another has been devised by Dr. Arthur Lederer and is in use in the laboratories of the Sanitary District of Chicago. At present, a committee of the laboratory section of the association was about to propose a provisional procedure for such a test.

A NEW MANGANESE STEEL.

An improvement in manganese steel alloys is announced in a recent United States patent. Commercial manganese steel contains from 11 to 14 per cent. of manganese, and hitherto any attempt to produce a steel lower in manganese than 10 to 11 per cent. has tended to make a metal nearly as brittle as glass and unfit for commercial use. The invention is based on the discovery, made by the inventors, that a certain critical relation exists between the percentage of manganese and the percentage of carbon employed with it in the alloy, and that by proportioning the carbon ingredients in accordance with this relation, a steel may be obtained containing from 6 to 9 per cent. of manganese, or as low as 5 per cent., and "possessing to a very valuable degree the characterictic combination of ductility with hardness and the other important properties of the richer alloys." It is believed that there is a practical limit, around 5 per cent., for the diminution of the manganese, according to the invention. The ingredients of the product are perfectly brought together in a molten state, as is usually the custom with manganese steel alloys. After casting, the metal is properly water-toughened. The new alloy is a poor conductor of heat and practically non-magnetic.

LARGE EGYPTIAN PUMPING PLANT.

One of the largest installations of pumps in the world is being made for the Egyptian government, to drain Lake Mareotis, near Alexandria. The plant will consist of eighteen pumps of the Humphrey type, each capable of delivering 100,000,000 gallons of water a day through a lift of twenty feet. Each pump is eight feet eight inches in diameter.

AN ALTERNATIVE METHOD OF MACHINE-FIRING BY COAL OR GAS.

As the question of gas-firing is apparently coming into prominence again in some parts of the Dominion, and as in some directions there is plenty of discussion on the subject, our readers will no doubt be interested in the interesting installation recently completed by Edward Bennis & Co., Limited, Little Hulton, Bolton, Eng., at the South Staffordshire Mond Gas (Power and Heating) Company's works at Dudley Port, Tipton. The plant comprises eight producers, each capable of gasifying 20 tons of fuel per day of 24 hours, and generating sufficient gas to drive gas-engines of 2,000 h.p. continuously. The total capacity of the present section is thus equal to 16,000 h.p.

The fuel is brought by boat into the canal basin, or by rail onto the siding, both having been specially constructed, and is loaded by hand into bunkers; the entrance to these from the boats is a little above water-level, and at the ground-level from the trucks. From these bunkers the fuel is automatically fed into two conveyers, each having a capacity of 40 tons per hour, and which convey and distribute the fuel into the storage bunkers over each set of producers. The bunker over each producer will hold 40 tons; i.e., sufficient to keep the producer working for two days.

The gas, after leaving the producers, is thoroughly washed in mechanical washers, and after passing through the ammonia recovery and gas-cooling towers, is further purified by large centrifugal fans and then passed through the scrubbers and the meters, before being compressed and sent through the mains for distribution. The machine-stokers, which are arranged to burn either coal or gas, are of the Bennis sprinkler type, of which an integral feature is the self-cleaning compressed air furnace. The boiler plant of the gas company consists of three Lancashire boilers each 9 ft. x 30 ft. with extended flues, working at 120 lb. pressure. They are fitted with superheaters, the gases discharging into an economizer containing 4,000 sq. ft. of heating surface. The total grate area of each boiler is about 57 sq. ft.

Some time ago it was decided to substitute mechanical firing for hand-firing, and a definite guarantee was given by the stoker-makers that the evaporation of each boiler should not be less than 12,000 lb. of water per hour, with an over-load evaporation of 15,000 lb. per hour when desired for short periods, and an efficiency of 72% was also conceded.

The qualified staff of practical chemists employed by the gas company were entrusted with the task of making tests which should establish the results of the work actually done by the boilers. The tests showed not only that the guarantees were maintained, but an appreciable increase on the figures had been achieved. For instance, the overload evaporation of 17,000 lb. of water per hour from each boiler, instead of 15,000 lb. per hour, was obtained.

The gas company, prior to the installation, had found no little inconvenience owing to the fact that steam was required to be kept both during the night and from midday Saturday until Monday morning, when it was desirable that labor duties should stand at a minimum.

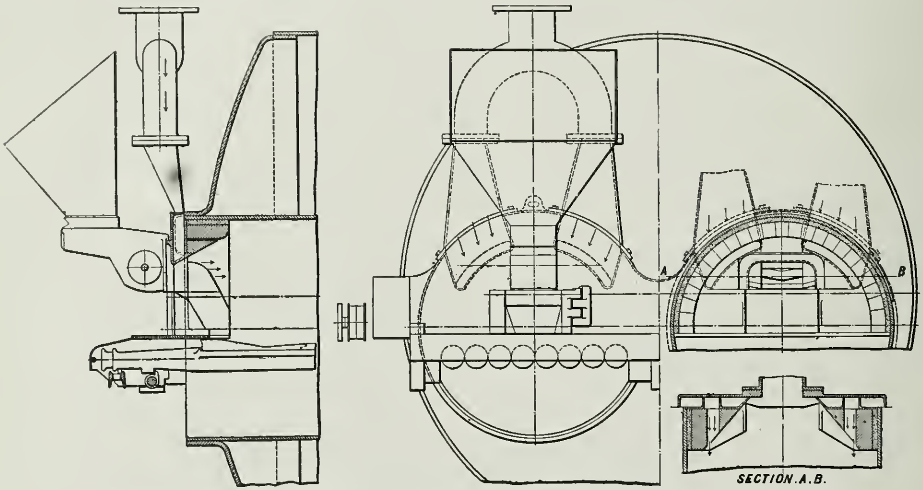

Fig. 2.—The stoker and self-cleaning compressed air furnace arranged for coal and gas-firing.

The problem was: could the mechanical stoking plant be so arranged that it could be coal-fed in the ordinary manner at ordinary times and the boilers gas-fired during the hours of night and at the week-ends? It was shown that, owing to the flexibility of the system of machine-stoking, illustrated herewith, the desired duality was perfectly practicable.

A reference to the illustration will show the gas ducts let into the top flange of the stoker front and secured by means of a gas-tight joint. The baffler plates which are situated behind the front are arranged with a passage, the outlet being over the grate; the gas passes thus from the ducts to the furnace. There are two ducts to each flue; that is, of course, four to each boiler, each pair containing a breeches pipe placed immediately behind the hopper and passing thence to the gas supply, constituting an extremely simple and satisfactory arrangement. It is, of course, essential that air should have access to the gas; a valve is, therefore, placed on the furnace front with an adjustable cover to regulate the amount of air supply. The air is conveyed into the furnace through a separate

air duct and does not mix with the gas until it reaches the inside of the flue where ignition takes place.

For four years this dual system of firing boiler furnaces has been in operation at the works mentioned, and the results have been such as to justify the firm in applying the idea to all their extensions of boiler plant, since the method was first adopted. Repeat orders have been placed for machines of the same pattern to those already supplied, for their new installation of boilers. The secretary of the gas company states that the thermal efficiency obtained during a six months' run under all conditions and variations of load, including times when parts of the plant were off for cleaning and inspection, was 73%. The average quantity of water evaporated per boiler per hour for a month's run was 14,880 lb. During this period the boilers were fired with slack during the day, and gas-fired during nights and week-ends.

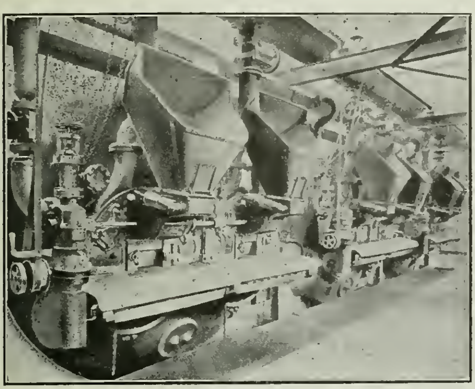

Fig. 1.—Stokers installation in the boiler-house of the South Staffordshire Mond Gas Company.

PRINCE RUPERT SHIPBUILDING PLANT.

The Grand Trunk Pacific dry dock and shipbuilding plant at Prince Rupert is being rushed to completion, and the close of the year will probably see all shops and tools ready for operation. The ship shed, served by two overhead cranes, is finished, as are also most of the auxiliary shops, including the boiler plant with its battery of six 400 h.p. water tube boilers; the power house, with two 1,000 k.w. generators, and electrically driven compressors to furnish air for the boring and driving tools. There is also a foundry capable of handling 20 tons of iron a day, a boiler and blacksmith shop with tools of large capacity and a machine shop with tools including a 76-inch swing by 50 feet between centres engine lathe, a 10-foot boring mill, a 6 by 6 by 20-foot planer, a drilling and milling machine, a 6-foot radial drill and many other similar tools.

Seven large pontoons have been built, three of them under the ship shed and four for the dry dock. Three of the latter are in place and the erection of the steel wings upon them is under way.

The machines have come in over the Grand Trunk Pacific lines. A yard locomotive crane has been used in their transfer to the shops. A 50-ton derrick has also been erected at the outer end of one of the piers.

PUBLIC UTILITIES AND THE PUBLIC.

At the Conference of American City Mayors, held at Philadelphia November 13 and 14, 1914, Mr. Delos F. Wilcox, consulting franchise and public-utility expert, New York, presented a paper which dealt in a clear-cut way with the factors which enter into the problem of relationship between the public and the privately owned public utilities serving it. The antagonism between the two bodies was commented upon in our issue of last week. This antagonism is responsible for the undue prolonging of many sorely needed developments, as the experiences of many of our cities will testify. Mr. Wilcox approaches the question from an intelligent and thoroughly studied position as the subjoined extracts from his paper show.

In discussing the antagonism mentioned above he observes that while this antagonism often assumes exaggerated, unintelligent and even fantastic forms, and while there is a substantial community of interest along many lines between the public and the utility corporations, we must not blink the fact that there is a permanent and fundamental conflict of motives between them. No amount of regulation and no possible development of good-will and the spirit of co-operation can change the fact that private corporations operating municipal utilities do so for profit and for as much profit as they can get, while the consumers and the public strive to get as much service as they can at the least possible cost.

The discussion of plans of campaign against high rates, poor service, political interference, financial tyranny and all the rest of the evils which we have set out to smite can only lead to confusion of counsels unless we clearly grasp certain underlying issues involved in the relations between the cities and the public utilities. Without having definite thoughts on these issues, we can not think straight on anything else, and without knowing what any particular speaker's thoughts upon them are, the rest of us can have no measure by which to gauge the importance or fathom the meaning of what he says.

The underlying issues are:

(1) What shall be the recognized character of public-utility investments

(2) What shall be the attitude of the city toward public utilities as money-earning enterprises?

(3) What attitude shall the cities take toward ultimate municipal ownership?

Mr. Wilcox answers these questions in the following manner:—

Character of the Investment.—Public-utility investments should be placed upon a non-speculative basis, and their security should approximate that of municipal bonds.

In the establishment of the non-speculative character of these investments, cities should not undertake to make good past losses.

So far as future investments in the standard utilities are concerned, the cities should assume the risks of loss due to unforeseen causes, and should substantially guarantee the integrity of all investments made at the request or with the approval of public authority.

Public Utilities as Money-earning Enterprises.—In my judgment, public utilities should not be regarded as a legitimate source of profit to be used for the relief of general taxation.

Compensation for franchise grants, and special taxes or license fees imposed upon public-service corporations should not be encouraged, unless the proceeds of such compensation or taxes are to be used in paying for the property.

Every individual public utility should be made to render a clear account of itself and, as a general rule, should be self-supporting.

Public-utility services should be rendered as nearly at cost as practicable, except that the rates should include a sufficient contribution to retire the investment within a definite period of time.

Public utilities should receive credit for all the service rendered by them to the city and its various departments, but only under unusual conditions should the city assume to subsidize a public-utility service out of the proceeds of taxation or otherwise.

Ultimate Municipal Ownership.—In my opinion, cities should not assume that public utilities are to remain permanently as private investments under private operation.

On the contrary, they should assume that all the well-established utilities will sooner or later be publicly owned, private capital being entirely excluded from the public streets except as it is loaned to the city.

In their franchise grants, and in all contracts affecting rates or granting privileges, the cities should establish the option to take over the utilities either at pleasure or at reasonable fixed intervals.

Wherever possible, the cities should go still further and without more delay definitely set in motion the machinery necessary to compel the gradual withdrawal of private capital from the public streets and the gradual acquisition of the utility plants by the cities as public property.

HIGHWAY INVESTIGATION IN SASKATCHEWAN.

The highway commissioners of Saskatchewan are endeavoring to secure accurate information dealing with every road in the province, and with this end in view the board has asked the collaboration of all councillors and secretary-treasurers of the rural municipalities. The officials are being supplied with maps and asked to supply information dealing with the following points: Graded roads in good condition, proposed roads already graded or new roads which should be graded, parts of proposed improvements that require immediate attention, graded roads that should be improved by cutting down hills and widening grades, government bridges not shown on the plan, bridges urgently required, etc. It will be seen from these questions that when the information is accurately tabulated the highways commission will have an accurate record of the condition of all roads in the province.

MANUFACTURE OF WOOD ALCOHOL.

In the course of investigations of the wood-distillation industry of New York by the college of forestry at Syracuse, it was found that the removal of the tariff on grain alcohol had hurt the market on wood alcohol in such a way as to make it hardly profitable to produce wood alcohol at this time. Chief products of the destructive distillation of wood are charcoal, wood alcohol, and acetate of lime. Charcoal is used for gunpowder, for fuel, in the manufacture of iron, and for various poultry and animal foods. Acetate of lime is used almost wholly in the dye industries. Wood alcohol is used largely as a solvent and for various chemical purposes. Beech, birch, and maple are the best woods for the production of wood-distillation products; heartwood is better than sapwood because it does not contain so large a percentage of moisture. Elm, chestnut, and cherry are not desirable woods for the wood-distillation industry because they contain too much tannin, gums, etc.

A Consolidation has been effected of the Lake Shore Railway Company and the New York Central Railway Company. The merger involves $300,000,000.

ROAD IMPROVEMENT.*

By W. A. McLean, C.E.,
Commissioner and Chief Engineer of Highways for the Province of Ontario.

THE present era is remarkable as one of rapid and convenient travel, transportation and communication. In this it is distinguished from all preceding ages. Invention has shown more marked advance in this phase of modern civilization than in any other. Every refinement has been sought, and vast expenditures have been made on steam and electric railways, ocean and lake steamship lines, harbors and canals, express, postal, telephone, telegraph and cable services. The motor vehicle is becoming a necessity for the transaction of business and even the air has been conquered as a practical medium for human locomotion. All these have not lessened but rather have increased the need for better common roads, and the demand for their improvement is accumulating with marked intensity.

The road situation of to-day presents many problems. It is doubtful if road conditions will ever be without their problems, for changes are constantly taking place, requiring an equivalent adjustment in methods of dealing with them. But it is also true that the present generation has opportunity to advance in this regard far beyond reasonable heritage or desires—for in general common road construction has been neglected, has been side-tracked and forgotten in the hurry of railroad construction.

New demands are pressing; advanced methods of construction are needed; old systems of organization are inadequate; old abuses and prejudices are persistent; opportunity for reform and progress is abundant and urgent.

The work of this association, and particularly that of the annual convention, is to its active members a matter of continuous but ever-reviving interest. Until the last ten or fifteen years, road construction in the open country was well served by water-bound stone and gravel, and was governed by established practice. Roads were built for horse-drawn traffic only, and the weight of loads was comparatively light. With the general use of rapid motor vehicles an entirely new form of wear has been added to that of steel tires and steel-shod horses; the weight of loads has largely increased, placing a much greater demand on road foundations and on bridges; the use of roads has greatly increased, especially on highways carrying suburban and interurban traffic. Road-building is in a reformative stage, and the annual accumulation of experience is steadily shedding new light on a very complex problem.

The growing difficulties of road construction and maintenance are not without their reward. The increased use of the roads means their increased usefulness. The possible service that may be performed by the common road is in proportion to the efficiency of the vehicle. The motor passenger vehicle and the motor truck have greatly advanced the general public value of the common road; and whereas good roads were regarded, a few years ago, as solely of rural concern, urban centres have become keenly alive to their value, and are willing to bear a fair proportion of the cost. The value of roads as a means of travel and transportation has increased manyfold. Instead of the farming population being expected to meet the entire cost, it is now fully conceded that, as regards

*Presidential address, American Road Builders' Association Convention, Chicago, December 15th, 1914.

main roads, cities must share the burden as with any other department of transportation.

Correlation of Facts.—The number of elementary materials used or dealt with in road-making is strikingly few, and, with minor exceptions, these materials are included in a brief list—sand, clay, gravel, broken stone, asphalt, tar, oils, vitrified brick, creosoted wood, stone setts, and Portland cement.

To these may be added a few materials of local service, such as oyster shells; or proprietary binders, such as Rocmac or Glutrin. While the elementary materials are few in number, the range in quality is wide, their combinations are many, conditions of traffic are of varying degree, and such factors as climate, workmanship and cost must be considered.

In the solution of road problems, at the present time, effort should be largely given by scientific engineers to the accumulation of facts respecting road materials and their action under climate and traffic. Much has been done in the past five years in this regard, and it is confidently expected that the next five will do more. Experience will then more nearly approximate the anticipated life of new materials and new methods. The status of knowledge respecting road construction in the next five years will largely depend on the care and thought with which we, at the present time, assemble and correlate obtainable facts. This is a matter which should be especially impressed upon municipal bodies, and co-operation with their engineers obtained, in order that experiment, test, and the collection of data may be effectively carried out.

Roads should be built according to traffic. To a proper solution of the problem of road construction and maintenance, there is much need of the general acceptance of uniform traffic standards. Traffic, in relation to the results from a paving material, is sometimes loosely described as "light," "medium" or "heavy." These terms have all grades of meaning according to locality. In one district 200 vehicles a day would be considered heavy traffic, while in another 2,000 vehicles might be medium traffic. When traffic standards have been clearly defined, and data is accumulated as to behavior and cost of a material under definite degrees of traffic, our experience can become of much greater usefulness. What is needed is a greater accumulation of fact, correlated with definite standards of traffic.

Work Should Not be Delayed.—Road-building is a slow process. In the northern States and Canada there are only about one hundred actual days in the year to be fully depended on. A mile a month for six months of the year is reasonable progress for one outfit of machinery.

There are limitations as regards labor and material which cannot be exceeded without greatly increasing the cost of the work. If a community needs a good general system of roads to-day the work should have been commenced twenty years ago. If a system is needed twenty years hence, it should be commenced now.

Permanent Roads.—The term "permanent" as applied to roads is somewhat misleading, and is not always appreciated by the general public. In the full sense of the word, there is no such thing as absolute "permanency." It is merely a relative term. But it is important, in making safe provision for financing road undertakings, that the matter be clearly understood. For all practical purposes, expenditure for the purchase of road allowance may be regarded as permanent; earthwork and certain drainage of an adequate kind may be regarded as permanent; substantial concrete culverts and bridges may be regarded as permanent; heavy road foundations may be permanent. But there is no such thing as a permanent road surface. Traffic and natural disintegration cause the wear and decay of any road surface that can be employed, and adequate provision should be made for the repair and renewal of the surface.

To meet the immediate needs of traffic throughout the United States and Canada, a large amount of construction must necessarily be carried on that cannot be considered of a "permanent" kind. To attempt the task of immediately building, for all traffic, roads that would have a maximum of permanence would be as impossible as it would be economically unwise. A large part of the farm traffic can, for the present, be best served by roads of moderate cost, lightly surfaced with broken stone or gravel, but carefully graded and drained. In many localities even good earth roads (but well graded and drained) maintained by use of the log-drag must be depended upon to meet the needs of traffic, owing to sparse population or the absence of local gravel, stone, or other suitable surface material.

The most unfortunate results have, however, arisen in the treatment of main roads on which, though expensively built, an effort has been made to maintain a heavy bituminous or other high-class surface on a totally inadequate foundation.

Much discussion has taken place during the past year on the subject of road foundations, and has arisen largely from those who attended the International Road Congress in London last year, as a result of their observation of practice in Great Britain and in Europe. European practice in all classes of permanent road construction has undoubtedly in the past tended to greater mass in the foundation than has been generally adopted on this continent. If past practice abroad has proven the need for the massive foundation, it would seem that, on this continent, the use of light foundations should be critically considered, with a view to the adoption of a greater depth of stone and the more general use of Telford or equivalent foundations, particularly for main roads, on which heavy traffic is assured. In the construction of strong foundations there is opportunity for permanency, which will at the same time reduce the cost of repair, for a large outlay may readily arise from attempts to maintain a good surface on an insufficient and yielding foundation.

Fair Distribution of Cost.—A fundamental necessity in creating a system of roads is that the cost shall be fairly and equitably levied on those who benefit. Failure to do so has done much to retard road-building in the past. If the general public feel that the cost of roads is borne in a reasonable degree by those who should contribute, much opposition will vanish. If the farmer feels that he is being asked to build roads for motorists of the cities, he is naturally opposed to proposals for road development on such a basis. Out of this has grown much of the opposition in some localities to the construction of trunk and State roads. A close study of the farmer's viewpoint by advocates of trunk roads will throw light on the road situation as a whole, and will indicate that a successful road policy in any province or state should make provision for the improvement, if not of all roads, at least of those more directly serving farm traffic. Broadly, trunk roads run from city to city, and are commonly parallel to the steam railway. The market roads on which rural traffic most frequently concentrates, radiate from the station, villages and shipping points, and are, in general, at right angles to the trunk roads so often advocated for motor traffic.

Trunk roads are a necessary adjunct of any system of roads. They are desirable, and should be built. They

frequently form part of a system of local market roads, but must be more substantially built to serve the more severe traffic.

It is difficult, however, for even the most patriotic farmer to rest satisfied with beautiful pictures and illuminative newspaper descriptions of the splendid roads of his own state—roads he never sees—while he has still to drive through the mud axle-deep to his local market or shipping point, with nothing being done to remedy that condition. Rural residents of every good farming community want good roads, and are willing to meet a reasonable outlay for them—nor are they opposed to trunk roads if the cost is levied upon the proper source.

A farming community, insofar as is consistent with its prosperity, can fairly be asked to contribute such amount per mile of road as would properly meet the needs of local traffic. For more expensive construction for motor traffic the remainder of the cost should be met from a source representing the contribution of cities or other communities benefited.

Market roads without trunk roads are commonly opposed by cities quite as much as the farmers oppose trunk roads when provision is not made for market roads. Upon a plan of road improvement which includes both, all the people can agreeably unite.

It is not intended to convey the impression that all roads can be built at a stroke, and that a durable road can be at once built to every farmer's gate. There must be a starting point. For this purpose certain roads must be selected for the immediate improvement, others to take their turn later. A study of local traffic conditions will indicate the roads on which traffic seeks to concentrate, and, commencing with these, the general system can be developed from year to year.

There should be no conflict of interest between the two classes of roads. The one is a necessary adjunct of the other in a complete system of roads. The great need is that the value of both should be recognized and adequate measures taken to develop both concurrently; but there should be no effort to substitute one for the other.

Bond Issues.—Much difference in opinion and practice exists with respect to the issuance of bonds for road construction. At one extreme are those who oppose all bonded debt for public roads, while at the other are those who advocate bonds maturing in forty and fifty years. It is probable that, as in most cases of widely divergent opinion, the true solution is in a moderate middle course.

The primary construction of a great system of roads has, in all countries, required large initial expenditure, such as can only be procured by distributing the repayment over a term of years. The construction of main roads, and even good market roads, is as a rule carried on in very disjointed sections, and at a sacrifice of workmanship, if the cost is provided by annual levy only. The necessary initial outlay can, as a rule, be sustained only by borrowed funds.

It may be asserted as a further truism that the term for retiring the bonds should not exceed the useful life of the work. Again, repayment in the briefest possible period is favorable in that the total interest charges are reduced.

In considering the matter, the road structure may be divided into several portions: The system of drainage; the earth sub-grade; the foundation; bridges and culverts, and the wearing surface.

Judging the future by past experience, it may be estimated that long-term bonds for certain portions of the work are justifiable. An effective system of open and under drains, deep cuts, extensive fills, and an adequate width of earthwork; a Telford, concrete or other heavy foundation; concrete or heavy steel bridges and culverts are all of long durability, and may justify long-term debentures. The road surface, on the other hand, has a comparatively short life, and will seldom justify a debt of more than five or ten years' duration. Adequate maintenance is in all cases essential.

The methods of finance as regards the issuance of bonds may thus be based on the life, not of the surface only, but of the several portions of the structure; the bonds for surface costs to be retired in not more than five or ten years, while the long-term period may be applied to what may be more truly termed the "permanent" portion of the work.

It might be logical to approach the matter on the basis of a general estimate, meeting a proportion of the cost, approximately 50 per cent., by long-term bonds, the remainder, or 50 per cent., covering surface costs, to be retired, according to the life of the pavement, in from five to ten years.

To go even further on the ground of safe finance, and to pay something for immediate benefit, a portion of the cost might be met out of the annual levy; but that as a rule is difficult, and may tend to reduce the amount available for adequate maintenance. It need not be added that to meet the cost of maintenance by the issue of bonds should be regarded as a criminal method of finance.

Town-planning.—Town-planning is a matter with which road-builders, we believe, should be closely identified. In this let us not be misunderstood. By "Town-planning" we do not mean the preparation of artistic plans and beautifully imaginative reports frequently employed for municipal advertisement and the promotion of speculative subdivision schemes.

The essential principles of town-planning are largely based on adequate provision for present and future traffic requirements, together with subordinate matters of street and road design.

The question of town-planning is one which should arouse interest in every progressive town and city. The United States and Canada are passing through a period of growth and expansion which, we trust, may long continue, and proper foresight in this regard is a necessity.

The past tendency to allow towns and cities to follow unguided growth has resulted in many objectionable and unfortunate conditions which could readily have been avoided, but which may now only be remedied at much expense.

The Housing and Town-planning Act of England, a recent measure, is accomplishing much, in enabling land-owners and municipalities to enter into agreements for mutual benefit. Main and radial thoroughfares are provided, parks and open spaces are laid out subject to agreement, industrial areas are set apart, residential districts are fixed, and streets, drainage, grades, water supply and many other details are decided upon in a manner that gives every opportunity for favorable and least expensive growth. The advantage to both the public and the land-owner is apparent.

No doubt many towns and cities on this continent, now comparatively small, are destined to a very considerable growth, and by well-devised measures, the gradual widening of existing streets, the opening of new streets, grouping of public buildings, etc., could be provided for; so that town-planning may be applied not only to new areas, but to the favorable treatment of old districts and the removal of existing defects. Practical town-planning

is of much value in meeting the present and future traffic needs of urban communities.

Present Financial Influences.—The influence of the war on the financial situation is a feature of much importance as regards the present and immediate future of road-building on this continent. On the declaration of war by European powers in August last, while much uncertainty was felt, there was remarkable freedom from panic in the money markets of the world. Since the commencement of hostilities there has been a decided improvement. Crops, on the whole, in the United States and Canada have been good, and farmers are receiving good prices for their produce. While the flotation of municipal bonds is difficult, and capital is showing a natural timidity, there is a growing tone of optimism which promises much.

While municipalities and state governments of the United States are feeling the effect of war conditions, Canada is more directly influenced, and is, at the same time, meeting a heavy war expenditure.

The borrowing opportunities for Canadian governments are restricted, and while loans for large undertakings are seriously handicapped, means are being developed through local capital to meet necessary and desirable outlay.

The construction of roads for war relief has been largely accepted as a logical measure, and while rural municipalities, with a continuance of good crops and prices, will be in an excellent position to carry on the work, the ability of provincial governments to aid large undertakings may not be correspondingly favorable. Here private capital has, in at least one marked instance, stepped into the breach, and the construction of a concrete highway from Toronto to Hamilton (about forty miles) has been organized and commenced since September 1st. A proposal to construct a main road from Montreal to Windsor, across the Province of Ontario (over 500 miles in length), as a great memorial to the Canadian expeditionary forces, has been received with much public favor, and it is not improbable that construction may be commenced as a war relief measure.

The final effect on road construction must largely depend on the duration of the war. Should the struggle, with its tremendous waste, be prolonged for three years, as is predicted by an eminent authority, the ultimate influence on financial conditions is impossible to estimate. Should it be concluded in a year, as many hope, the present feeling of optimism will assuredly not be without substantial foundation.

RAILWAY CONSTRUCTION AT SALISBURY, ENGLAND.

Large numbers of the Canadian troops at Salisbury have recently been engaged in the construction of a light railway to serve their various camps. The roads, which were of a temporary nature, had given way under the strain of heavy tractor and motor truck traffic, engaged in the haulage of supplies. A contract was awarded to Sir John Jackson & Co. for the construction of this service railway, and Canadian engineers, many of them graduates of the universities of this country, Toronto, McGill and Queen's, are engaged in its construction.

In addition, the Canadian engineers have charge of the construction of a water supply system at Bulford and Larkhill.

THE EFFECT OF FROST UPON CONCRETE.*

By John Hammersley-Heenan, Assoc.M.Inst.C.E.

THE engineer who is called upon to carry out work in Canada during the winter finds that the methods of construction which were satisfactory in the summer will need considerable modification to suit winter conditions.

Concrete work, especially the lighter forms of reinforced concrete, used in building construction needs greater care and supervision. As a result of considerable experience gained during the last few years, it can be said that the freezing of concrete will not damage it if it has first had a chance to set under favorable conditions for about two days. The effect of the freezing is simply to delay the process of hardening, which will again proceed under suitable conditions, and will eventually attain its full strength. If concrete is frozen before it has commenced to set, it will not be injured if precautions are taken to prevent it from freezing again after it thaws until it is sufficiently hardened to withstand the effects of subsequent freezings. It is alternate freezing and thawing during the process of setting that causes the damage.

To meet the foregoing conditions, when carrying out concrete work in winter, it is necessary to devise means of mixing the concrete with materials freed of frost, placing it in the forms before it has commenced to freeze, and then protecting it and keeping it warm for about two days. After that it may be allowed to freeze without fear of its being damaged.

In the case of concrete in mass, of large bulk, it is unnecessary to apply external heat, as the large body of concrete will generate sufficient heat during the process of hardening to enable the mass to set; all that will be necessary is to protect the outside of the concrete so as to keep the heat in. This can best be done by covering the concrete with clean straw.

For light sections of concrete, such as in reinforced concrete, poured at a temperature not below 22 deg Fahr., some engineers allow salt to be used in a proportion not exceeding 10 per cent. There are many arguments for and against its use. The author prefers not to use it, except in marine works when the concrete is mixed with sea-water and the salt is admitted in that form. He has found that, instead of using salt, good results will be obtained for temperatures that do not fall below 22 deg. Fahr. by heating the water with a steam-hose taken from the mixer-boiler, and when necessary placing a few coke or wood fires on the heaps of sand and crushed stone, the usual precautions being taken to protect the concrete when in the forms, as described later.

For lower temperatures than those referred to above greater precautions must be taken to heat the ingredients by means of steam coils or radiators.

The concrete having been mixed, and the portion of the work to be carried out decided upon, the floor immediately below it should be partitioned off with tarpaulins, and coke stoves arranged under the floor slab, allowing about one stove to every 800 sq. ft. of floor space. All loose dirt and snow must be removed from the forms with brooms, and a steam hose should be applied to remove all ice and frost, the steam playing continuously over the forms in advance of the concrete, thus

*From a paper read at a meeting of the Institution of Civil Engineers (Great Britain) December 2, 1914.

warming them in readiness for the concrete. The concrete should be poured quickly and continuously, and as each section is completed a tarpaulin may be drawn over it, supported on wooden strips about 6 in. above the surface of the concrete. In most cases this protection will be sufficient, but during very cold weather it will sometimes be found necessary to form a sort of tent over the floor, in which extra stoves are placed to protect the workmen and the upper surfaces of the concrete.

Great care must be taken to have the fires kept burning continuously for two days, after which the concrete may be allowed to freeze without fear.

The work must be examined from time to time until it is found to be hardened sufficiently. During summer working the author has allowed the supports from the underside of slabs to be removed in four days, but on other occasions four weeks have not been found to be too long.

There are many examples of concrete works which have stood the test of time without showing any signs of being affected by frost; but, on the other hand, a few cases have been reported of very serious corrosion due to the action of frost, such as bridge piers and reinforced-concrete piles.

Judging from the information available at present, concrete exposed in air in a dry locality need not be affected by frost any more than good building stone, and probably it will stand much better. Concrete always submerged under water is protected and need cause no anxiety. But concrete alternately wetted and frozen must be protected from frost. On work which is being carried out at Halifax, Mr. John Kennedy, M.Inst.C.E., is protecting the concrete piles between high and low water with a covering of wood about 2 in. in thickness, which it is hoped will prevent the action of frost.

TWO TELEGRAPH SYSTEMS AMALGAMATE.

An arrangement has just been consummated between the Great North-Western Telegraph Company and the Canadian Northern Telegraph Company. Commencing on January 1st, 1915, these two large telegraph systems will be operated as one under the name of the Great North-Western Company. Within the next few months, the lines and offices of the Western Union Telegraph Company in the Maritime Provinces will be operated by the Great North-Western Company, which will then have the largest telegraph system in Canada, it covering the country from the Atlantic to the Pacific. They will have over 1,700 offices in Canada and direct connection with 22,000 offices of the Western Union Telegraph Company in the United States, as well as with eight transatlantic cables, six of which have landing stations in Canada. This insures to the Canadian public a telegraph and cable service with and from Canada unique in its completeness.

Mr. Z. A. Lash, K.C., continues as president, and Mr. Geo. D. Perry as general manager of the Great North-Western Company.

Scientifically speaking, there is no such thing as a waste product, and the word waste has become current because of the lack of knowledge of how to transform residual matter into a marketable commodity. In the study of fuels, for instance, the enormous quantities of carbonaceous substances which exist in different forms, and which have not been utilized or treated in order to extract from them the valuable products they contain, are now being brought into the sphere of commerce by the introduction of new processes. A study of the history of these processes is exceedingly interesting, and indicates very clearly how the theorists have been groping towards the end which appears now to be susceptible to early attainment.

SHEAR AND PROBLEMS ARISING THEREFROM.*

By H. Kempton Dyson.

THE determination of stresses and strains in materials has formed the subject of many investigations. The usual mode of attacking the problem involved has been often referred to as the "mathematical theory of elasticity," which is, however, an all-embracing title that should rightly cover the whole subject. In its narrower aspect it means the mathematical analysis of stresses and strains in an elastic medium that is homogeneous and non-granular. Seeing, however, that such a material is purely imaginary, the mathematical analysis, though strictly exact in itself, may not conform to the facts of the experiment. The mathematical analysis that has arisen from such consideration is a most powerful assistant to the engineer, and by the adoption of suitable functions to suit the peculiarity of the composition of each material, will, within the limits of elasticity, afford many important relations that accord with the facts determined by experiments. Mathematics, including, in large part, the processes which have been evolved by consideration of the ideal elastic substance, have only comparatively recently been applied to another mode of approaching the determination of the stresses and strains in materials in which their granular nature is recognized and their resistance and deformation expressed in terms of the intermolecular forces and motions. Prof. Sir J. A. Ewing has put forward in a tentative way a theory of electrical attraction between molecules, while Prof. A. Rejtö, of Budapest, has worked out in considerable detail a theory dependent upon molecular friction.

Various hypotheses to account for rupture in bodies under stress have been advanced by writers from the point of view of the mathematical relations of a homogeneous, non-granular elastic material. Lame assumed that material was ruptured when the greatest tensile stress reached a limiting value. Poncelet, followed by Sain-Venant, assumed that failure occurred when the greatest extension reached a certain limit. Tresca, followed by G. H. Darwin, suggested that rupture occurred at a limiting value of the largest difference of the greatest and least principal stresses, while Colomb made a somewhat analogous suggestion that failure occurred when the greatest shear reached its limiting value. This view, in recent years, has received much support from experiments conducted by Mr. J. J. Guest, with the consequence that it is often termed "Guest's Law."

The stress at any point can be completely specified by only six components on rectangular axes, three being normal and three tangential to the three planes, in which three axes lie, and further, three planes can be determined upon which the resultant stresses are wholly normal. Such planes are called principal planes, and the stresses across such planes are called principal stresses. The directions of the principal stresses are generally called the axes of stress.

Various experiments on steel and cast-iron specimens under combined stresses clearly seem to show that when rupture occurs the maximum shearing stress is far more constant for ductile materials than the maximum principal stress, but not so for a brittle material like cast iron, where the reverse order of things applies. Brittle materials are weak in tension, and the author of this paper

*From a paper read December 3, 1914, before The Concrete Institute (Great Britain).

offers the opinion that rupture of materials ductile occurs by shearing, but that rupture of brittle materials occurs by tension. Rupture by compression stress alone never occurs. If materials are ruptured under a thrusting load it is by the shear or the tension that is induced thereby, as will be referred to in greater detail hereafter. It is suggested that ductile materials are distinctive in their structure in that they are crystalline in structure and appear to break down by sliding along the cleavage planes of the crystals.

The writer, working on his assumption that brittle materials of distinctly granular structure fail by weakness in tension, has made an analysis of the conditions of rupture of a granular mass in which there is cohesion. The analysis proceeds on allied lines to Rankine's analysis of frictional stability, with the difference that cohesion is not ignored. Various analyses of the stresses existing under such a mode of failure have been put forward by writers on the strength of materials. It has been supposed that brittle materials under stress should fail on planes inclined at an angle of 45 degrees to the direction of the stress. With ductile materials under direct tension the analysis appears to be approximately correct, though Prof. Rejtö contends that the angle of slipping is a characteristic property of the materials and varies with different materials. It is well known that tension specimens draw out at the point of rupture into a conical and cup-like form of fracture, the angles at the faces of the cup being approximately 45 degrees.

In compression, however, with ductile materials the relation does not appear to hold with the same degree of accuracy, the very nature of ductile materials being to swell in compression, and as they swell so their area increases. The stress cannot be increased beyond a certain point, at which they become permanently deformed, according to geometric laws, so that there is no indication of elasticity or tendency to return to the primitive shape. By microscopic inspection of the faces of such compression blocks a justification of the ordinary analysis is, however, found in that ridges are noticeable upon the surfaces showing where the material has slipped upon the cleavage planes of the crystal structure, which slippings occur approximately at 45 degrees. The customary mode of analysis proceeding on the lines of the mathematical theory of elasticity for non-granular and homogeneous elastic solids, as we have seen, leads to the reasonable explanation as regards ductile materials. Navier made a further assumption in an attempt to explain why brittle material did not fracture on planes at angles of 45 degrees, but, as with cast iron and concrete, at some angles inclined in the neighborhood of 30 degrees to the axis of the compressive stress. His assumption was to consider that materials failed by sliding on an oblique plane, and that the friction on that plane had to be overcome as well as the shearing resistance of the material. The author of this paper was led to his other mode of analysis whereby the material was considered as a granular mass with cohesion, by knowing that later experiments did not appear to agree with the values derived by Navier's analysis. Experiments had, indeed, shown that the resistance of concrete to direct shear was very different to the shearing value which was found by Navier's analysis, and punching experiments on concrete specimens again showed different values. The shearing values for concretes determined by different modes of analysis and experiment were found to be different. It remained, therefore, to see if some reasonably uniform relation could be found between the resistance to shearing forces derivable from experiments on direct shear, and from the analysis of the shear stress induced by direct compression. This relation appears to consist in the dependence of the resistance to shear upon friction and cohesion, or as the latter might equally well be termed, tension. A uniform relation is found between the experiments on building stones, concrete, and cast iron in respect to failure under tension, compression and shear. The author next refers to the relations between the bending moments and shearing forces on beams.

Reference has already been made to the fact that experiments tend to show that rupture of ductile materials under compound stress occurs by shearing stress on oblique beams, to have regard to the point where maximum shear will occur. This is often calculated for vertical or horizontal planes, but it requires determination on oblique planes. As regards joist sections, if the web were fairly slender the maximum intensity of shear stress is found at the connection between the web and the flange and not upon the extreme fibre. This points to the conclusion that our standard sections ought to be investigated with regard to their possible weakness at the shoulders,, as such weakness might be very serious in beams of short span.

It is well known that webs need to be stiffened by the provision of vertical stiffeners under point loads to prevent crushing and buckling of the web, and the provision of stiffeners to prevent the rib buckling by diagonal stress is also adopted more or less empirically (seldom by theoretical determination) in the case of plate girders. From the fact that the directions of the principal stresses crossed each other at right angles, at an inclination to the neutral axis of about 45 degrees, the web is in the condition of a strut, so that stiffeners may require to be provided either in the form of vertical or inclined members in order to convert the plate girder into a lattice girder.

In reinforced concrete we have a somewhat analogous position. Reinforced concrete beams are quite a distinct type in themselves, because they pass through two stages in their resistance to cross-breaking. In the first stage the steel remains uniformly connected to the concrete in which it is imbedded. In the second stage the steel slips through the concrete for part of its length and the concrete cracks in the tension portion, so that the beam becomes converted into a form of construction which, in different modes of reinforcing, would appear to consist of either a concealed arch with a steel tie, a trussed beam analogous to the trussed timber beam, or a frame. Frames subjected to transverse loading are, of course, subjected to shearing forces, but the effect of the shearing forces is naturally very different on frames from that on a girder with a solid web or upon arches. A shearing force diagram only consists of the plotted values of the tendency to shear it asunder which the load exerts upon the structural member. We can, therefore, have a shearing diagram equally applicable to a beam, an arch, or a frame, but the manner of using the diagram for determining the internal stresses which result from the shear forces must be different in each case.

Persons may be misled in connection with shearing force diagrams as applied to frames by reason of the similarity between the use of the diagram for calculating stresses in a beam and frame. Whereas the application is close in the case of concentrated loads applied at the connection points of the frame, in the case of distributed loads the shearing force diagram is not so closely related. The fact that the area of the shear force diagram up to any point is equal to the numerical value of the bending moment at that point in the case of freely supported beams will often be found of considerable service in

practice, while the feature that the point of maximum bending moment is the point of zero shear, which is of general application to free, fixed, and continuous beams, is of common employment for the determination of the maximum bending moment.

The fixing of one end and one end or the other have an effect upon the distribution of the shear along the length of a beam. Partial fixity as occurs with continuous beams will affect the shear in similar fashion, and it should be noted also that partial loading of continuous beams (i.e., loading any or all of the spans wholly or in part) will result in different distributions for the shear and gives different reactions on the supports. For this reason the current practice of generally taking the load on the support next to the end of three or more continuous equal spans as equivalent to the load on one span is considerably in error, as is the practice of taking the shear as the same as on a freely supported span. For the determination of shear throughout the length of beams required to sustain travelling loads where these point loads are applied at several points of the span and can move throughout the span, use is made of influence line methods. The shear in the webs of beams is applied to the flanges. This may be considered generally as a gradually increasing thrust from the ends of a beam and tends to cause lateral flexure of the compression flange considered as a long strut.

When the web is stiffened either vertically or obliquely, the stiffeners act as struts, and the web takes diagonal tension like the diagonals of a frame. This diagonal tension tends to cause vertical secondary bending of the flanges between the panel points, which should again be taken into account in the detailing of plate girders.

If the stiffeners are arranged vertically, they convert the girder into practically a Pratt truss, where the stiffeners are in compression. If the spacing of the stiffeners is closer together than the arm of the beams apart, the diagonal tension may still be considered as inclined at 45 degrees, the system becoming one of superimposed trusses. If the stiffeners are diagonal the girder becomes an N-truss. In riveted joints not only the shearing resistance of the rivets but the safe-bearing stress on the plates or other members through which they pass must be studied. Very often the bearing stress is less than the bearing resistance. In using that value, however, it should be remembered that the holes in which the rivets are inserted are punched or drilled large enough to enable the rivet to be inserted easily. Consequently, when the rivet is closed it will have the larger diameter of the hole.

Reinforced concrete beams are quite a special form of construction, because the stresses are induced in them in different ways according to different modes of arranging the reinforcement, and according to the amount of reinforcement; that is to say, a reinforced concrete beam may prefer to act as a flat arch with a tie rod if it is able to hold up in such a form with less stress than it would in some other fashion. On the other hand, if it acts as a beam, the conditions are different in the case where the stress is such as not to have ruptured the concrete by tension therein from the case where the concrete is cracked. Generally, some parts of all reinforced concrete beams are in the uncracked condition, and really require analysis on the lines of a homogeneous section, the materials, however, having different moduli of elasticity both for the concrete in tension and compression and the steel. In the majority of cases the reinforcement is insufficient in amount to prevent cracks occurring at some point or points in the beams, and then when cracks appear it means that the steel has moved in the concrete, and that the construction either consists of a trussed beam or a framed beam in part or in whole. Where the reinforcement is inclined at the ends there is an obvious analogy to a trussed timber beam. Such a type of reinforcement is quite appropriate for point loads. When the cranked bars are in combination with straight horizontal bars a practical type of reinforcement is provided which forms a sort of half-way house, and can equally well resist point loads or distributed loads. In the latter case not only do the straight bars produce one sort of beam action, but the cranked rods resist the shear in that the inclined pull in the bars affords a vertical component at every part of the length to resist the shear.

The resistance to the shearing force of a beam must, in the presence of cracks, be altered to the manner in which an arch, a truss, or a frame resists shearing force. Diagonal cracks in nowise preclude the concrete from taking diagonal compression parallel to such cracks.

It was early found in practical work that it was advantageous to reinforce beams against shearing force in other manners than by trussing members. Either alone or in combination with such vertical reinforcements, web members (either vertical or diagonal) were provided. Numerous patents have been taken out for various forms of separate web members, though often they can be economically provided by turning up the main bars. Where other practical and theoretical conditions preclude one from using so many bars as would enable one to turn up the bars at the proper additional separate members the system may be a double one. The frame action of vertical and inclined web members generally belongs to two types. In the first case, where vertical web members are employed the construction becomes a kind of N-truss, in which the concrete forms compression members and the steel the tension members. In the diagonal form the construction becomes practically a lattice girder. In both types of construction the frames may be, and often are, superimposed; that is to say, the spacing of the vertical members or of the diagonal web members is frequently fairly close.

It should be borne in mind that the theoretical analysis of the stresses in materials is in the nature of a speculation; it is an attempt like all scientific theory to explain the facts, but with the progress of investigation further facts come to light which cause us to modify the former theory. In that way there is a gradual improvement and greater exactitude about theories. But their chief purpose must always remain to draw the attention to the practical engineer to what is happening, likely to happen, or what may possibly happen, and in practical design the complications of refinements in theory are too great to permit of adoption. The practical engineer, by study of the theory, will, however, be able to make his own simplifying assumptions for approximate calculations, which will enable an economical and safe structure to be erected satisfactory in all the directions indicated by elaborate analysis.

Moore's wharf, which handled all the shipping at Skagway, Alaska, including freight for the interior over the White Pass Road and the Yukon River, was destroyed by fire, the loss being estimated at $60,000. Warehouses and contents valued at $150,000 were also wiped out.

Asphaltic concrete must be laid hot and rammed until the surface is smooth. Care must be taken that the materials are properly heated, that the place where it is to be laid is absolutely dry, and that ramming is done before it chills or becomes wet. The rammers should be heated in a portable fire.

Editorial

NICKEL PRODUCTION AND CONTROVERSY.

Since the beginning of the war the daily press has given much space to editorial discussion of the export of nickel. Last week the president of one of the large refining companies issued a statement, as a result, no doubt, of the adverse criticisms which have been given publicity here and there. The point at issue is whether or not the metal, or its oxide, finds its way either directly or indirectly to the armament manufacturers of the enemy, after it has been reduced at refineries, none of which are situated in Canada, the metal therefore being exported before treatment.

A statement of the world's nickel production, and the demand that there is upon it, may not be amiss.

Of the total production, that of Canada forms by far the greater part, and this country has been looked forward to by all world powers, as the source of the metal. The nickel mines of Ontario, chiefly around Sudbury and Coniston, loom large in the affairs of the manufacturers of many important commodities. Of the mineral output of Canada, Ontario comes first with over 40%, British Columbia produces 20%, Nova Scotia 13.4%, while the output of the other provinces is in each case below a rating of 10%. Of the metallic output, nickel is second in quantity (copper leading by a wide margin), and third in value (silver and gold being ahead of it). Of this nickel production, the Sudbury and Coniston mines turn out all except 0.06%, which comes from Dundonald Township, also in Ontario. Compared with the output of the world, Ontario's production in tons is as follows:—

Year.	World's production.	Ontario's production.
1913	30,000	24,838
1912	28,500	22,421
1911	24,500	17,049
1910	20,100	18,636
1909	.....	13,141

The balance of the nickel supply, *i.e.*, what is not produced in Canada, is largely controlled by France and comes from the mines of New Caledonia, which, in 1913, produced about 5,000 tons of matte.

The remaining countries that possess nickel deposits, small in size and importance, are the United States, Norway, Greece and others. Some of the mines, chiefly those in the United States and Norway, ceased operation owing to the great Ontario development. That their production was small is evidenced by the fact that fifteen years ago the annual production of nickel ranged around 7 tons.

The much-talked-of metal has an important use in nickel plating and coinage, but the publicity centering around it at the present time is because of its vastly greater use in the manufacture of nickel steel. Besides its consumption in bridges, etc., nickel steel is much used in the manufacture of armor plate and in many kinds of war munitions.

Since France and Canada, the producers of this coveted ingredient of material for siege guns, etc., are not allied with the manufacture, for Germany, of these and other instruments of war by Krupp's and Tyssen, it has been a matter of considerable comment as to the source of nickel supply that is being drawn upon at the present time by the enemy. In this connection it is interesting to go back to a number of years ago when the suggestion was made, and obtained considerable support, that the export of Ontario nickel ores, matte, or metal, should be prohibited, or limited, to all countries other than Great Britain. The question was considered of vital importance at the time, and since the outbreak of the present war it has received considerably greater attention. Late in October an Order-in-Council was issued by the Canadian government prohibiting the export of nickel to alien countries. It read: "To all foreign parts in Europe and on the Mediterranean and on the Black Seas, save Great Britain, France, Russia (except the Baltic ports), Spain, and Portugal."

As the result of this prohibition (considering it for its effect on mineral production alone), it must be expected that other countries will revive the mining of nickel to as large an extent as possible, and that nickel statistics for the next year or two will probably show the effect of this incentive. Norway's ore contains as high as 2% of the metal, and the electrolytic refineries at Christiansand, with a capacity of about 400 tons annually, are now reported to be at work. Something is to be said about electrolytic nickel, in that, although it has a high degree of purity, the power consumption is so large as to render the process uneconomical, except in a country where current is low priced, as in Norway. Except for a relatively small recovery of nickel in connection with the electrolytic refining of copper, the United States depends entirely upon the Sudbury mines for its supply.

Although Canada figures so prominently in supplying the world with nickel, she has neither nickel refineries nor nickel-steel mills of her own. Processes have been tried out during the past quarter century, but with no success from an economic point of view. The result is that our raw material leaves the country, the Mond Nickel Company sending its product to Wales, and the International Nickel Company refining its metal in New Jersey. Thus the question of what are purported to be economic conditions prevails over ideal conditions, and the Canadian nickel industry is an industry only in so far as it raids a very important natural resource.

Observations have been made, although there is no proof of foundation, that Germany has been drawing her supplies of nickel for naval armament indirectly from the Canadian nickel mines in the Sudbury district. Once the matte is exported, it is claimed, the refiners are at liberty to dispose of the refined product as they please. The proportion which under normal conditions finds its way into the German market, has been stated to be about 60%. The criticisms are illuminated by the allegation that the Krupp Company were, when the war broke out, influential stockholders in one of the nickel corporations. It is further stated that the requirements of the government, that companies with Dominion charters file a list of shareholders annually, has not been complied with in this particular instance.

Whether any or all of these observations are founded upon truth, it is hard to state. At any rate, the latter add fuel to the argument of the former, and to the implication that the Canadian government's Order-in-Council is not preventing an important product of the Dominion

finding its way to the enemy, to be used against the British Empire in the present conflict.

Mr. Monell, in his recent announcement, as president of the International Nickel Company, emphatically states that full information as to the destination of shipments of nickel, made by his company, has been in the possession of the Dominion authorities since the outbreak of the war, and that they are currently kept cognizant of all exports of nickel, as well as of all local shipments of the company. It has been stated that no sooner were hostilities declared than the government and the company had a mutual understanding, and the former was given assurances that no part of the output would be furnished either directly or indirectly to Germany or Austria.

This is the situation and we are not venturing any recommendation to the British Admiralty, in competition to a number that have already been given publicity, some of them displaying more crudeness than loyalty to the welfare of the Empire. It would appear that a number of writers on the subject have overlooked the fact that the British War Office is a remarkably wide-awake organization, and that it is impossible to conceive of its having overlooked the importance of the nickel situation. The co-operative scrutiny to which nickel is being subjected by the Canadian and British governments is such as to warrant a continued production, and assurances that no part of it is being employed by a country unfriendly to the Empire. At the same time, it brings clearly to our mind how desirable it would be if Canada at the present time handled the nickel situation from the ore to the finished product. It is to be hoped that the national security involved therein, as emphasized in the present controversy, will lead to a counteraction against the argument that refinement of nickel at the point of production is not, in this instance, the best procedure. To say that with the present state of the art any material change in such economic conditions (as at present exist) would react in a manner most detrimental to the Canadian nickel industry, is to make a statement that is not self-supporting.

PROPOSED STANDARD SPECIFICATIONS FOR ONE-COURSE CONCRETE STREET PAVEMENT.

IN our issue of December 17th, 1914 (page 753), appeared a set of proposed standard specifications for one-course concrete highway. These specifications are to be submitted, for adoption, at the February meeting of the American Concrete Institute. Another set to be submitted covers one-course concrete pavement and is almost identical with the specifications published in the article mentioned above. The clauses and other respects in which there is a difference are enumerated below.

The two sections devoted to materials and grading are identical, with the exception that the cross-sectional drawings and profile referred to as Fig. 1, in the former set, refer to Fig. 1 as presented herewith. Section 3 is as follows:—

17. Drainage.—The contractor shall construct tile or other drains as shown in the drawings attached hereto. Tile to be laid in the trench at least............inches wide, and............feet deep below the top of the adjacent curb. Such trench shall be back filled with crushed stone or pit run gravel with sand removed, which after light tamping shall be....... ....inches in depth.

18. All catch basin and manhole tops and all covers of openings of any kind shall be readjusted to the grade by the contractor at his expense.

Section 4, on subgrade, is identical with the exception of the second paragraph, which reads: "The street shall be graded from curb to curb to the proper subgrade to permit of the specified thickness of paving materials being laid to bring the finished surface of the pavement to the lines and grades as shown in the plans."

Section 5, devoted to forms, is the same in both specifications.

In Section 6, the note referring to crown and thickness of concrete reads as follows: "The thickness of the concrete at the edges shall not be less than six (6) inches. When pavements twenty (20) feet or less in width are to be built on approximately level ground and a flat subgrade is to be used sufficient fall for drainage at the sides of the pavement along the curb shall be provided by giving the roadbed the same grade as that proposed for the gutter. The crown of all pavements shall not be more than one-one-hundredth (1/100) of the width, except when deemed advisable by the engineer—the crown of a pavement built on a crowned subgrade may be increased to one-fiftieth (1/50) of the width to provide sufficient fall for drainage along the sides of the pavement at the curb."

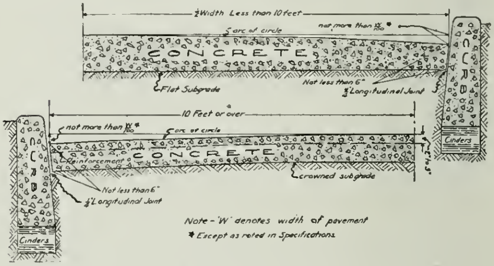

Fig. 1.—One-course Concrete Pavement.

In the section covering joints the figure referred to is Fig. 1, as shown herewith.

Specifications covering measuring materials, mixing concrete, reinforcing, are the same in both specifications. In the clauses covering the placing of concrete, that having to do with finishing, in this instance, reads as follows:—

36. Finishing.—The surface of the concrete shall be struck off by means of a template or strike board, which shall be moved longitudinally or crosswise of the pavement. Concrete adjoining the metal protection plates at transverse joints shall be dense in character, and any holes left by removing any device used in installing the metal protection plates shall be immediately filled with concrete.

After being brought to the established grade with the template or strike board, the concrete shall be finished from a suitable bridge, no part of which shall come in contact with the concrete. The concrete shall be finished with a wood float in a manner to thoroughly compact it and produce a surface free from depressions or inequalities of any kind. The finished surface of the pavement shall not vary more than one-quarter (¼) inch from the true shape.

The specifications relating to curing and protection, and to the construction of shoulders, are the same in both.

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CONTENTS.

BOOK REVIEWS.

Pumping by Compressed Air. By Edmund M. Ivens, B.E., M.E. Published by John Wiley & Sons, New York City; Canadian selling agents, Renouf Publishing Company, Montreal, Que. First edition, 1914. 244 pages, 106 illustrations, 6x9 ins., cloth. Price $3.00 net. (Reviewed by A. S. L. Barnes, Hydro-Electric Power Commission of Ontario.)

This book forms a welcome addition to the comparatively scant literature of the subject with which it deals. While the efficiency of this method of pumping is admittedly low, there are undoubtedly cases where its advantages in other ways outweigh this drawback. For example, to adopt it for pumping clean water to a high head, in a case where there would be men available for attending to the plant at all times would, in most cases, be fallacy but to pump sewage to a moderate head at, say, some underground point, as is frequently done, where special attendants would be needed to look after a comparatively small isolated plant there can be few systems comparable with pneumatic sewage ejectors, which carry out the functions of pumping by compressed air and can at the same time handle sewage as no ordinary form of pump could do, while their action is entirely automatic.

The author cites a case of an air pumping system, for water replacing an old steam pumping plant, in which an over-all efficiency of only 24 per cent. was obtained, albeit an over-all saving of $1,310 per annum was effected.

In this particular case it would, however, be interesting to know what saving could have been effected by putting in a modern steam engine and dynamo driving an electric motor coupled to a turbine pump.

Compressed air pumping is being rather extensively used now for another purpose, viz., pumping water from wells. To accomplish this, several different systems, all embodying the same basic principle, but differing in detail, have been devised. The idea is to force air down the well, under pressure, and allow it to bring up some water in traversing its natural upward path to the ground or some higher level.

Owing to the very low efficiency of these systems at high heads it is preferable, if the total lift be considerable, to carry it out in two or more stages if the conditions will warrant this being done.

Careful and well-illustrated descriptions of several of the best known systems of this kind are given in the book, together with a statement as to their advantages and limitations.

The book is well written, and where formulae are introduced they are of a simple and easily understood nature. The two closing chapters deal respectively with the "flow of compressed air in pipes" and the "flow of water in pipes." At the end is a copious index. The work should prove very useful to both the student and the engineer engaged in dealing with pumping problems.

Concrete-Steel Construction, Part I., Buildings. By Henry T. Eddy, C.E., Ph.D., Sc.D., and C. A. P. Turner, C.E. Minneapolis. First edition, 1914. Published by the authors. Cloth, 6x9 ins., pp. xv.+438, 98 illustrations. (Reviewed by C. R. Young, B.A.Sc., C.E., assistant professor of Structural Engineering in the University of Toronto.)

Although the object of the authors of this book is to advocate concrete-steel construction in general and the mushroom system in particular, the work shows some attempt to cover the general principles of design and execution of reinforced concrete work in buildings. In their efforts to secure the adoption of methods of design that will permit reinforced-concrete construction to successfully compete with timber construction, they do not always remain on firm, well-tried ground. To the discriminating reader, however, the book will be a valuable one.

The text is divided into fifteen chapters. Some of these are given captions, but for about half of them the variety of subjects treated in a single chapter is so great as to preclude their comprehension in a single heading.

Chapter I. is of general interest and applicability. It covers the origin of concrete construction, materials, mixing and handling of concrete and forms. The treatment of the last subject is meagre, the only design shown being one for a column used in connection with the mushroom system.

Chapter II. deals with general types of floor construction, variation of strength with thickness and span, theoretical treatment by proportion of typical panels and deflection of slabs.

Chapter III. is devoted to beams. The methods of analysis and design presented are those of the Joint Committee, except in the matter of diagonal tension and bond which are given original treatment.

In Chapter IV. beam action and slab action are compared through the application of the laws of bond shear and the theory of work, and in Chapter V. is presented the authors' theory of the strength and flexure of the standard mushroom type of construction. The method of analysis followed is, in general, that already set forth by Dr. Eddy in his book "The Theory of the Flexure and

Strength of Rectangular Flat Plates." Indeed, this monograph has been incorporated in the present volume. The soundness of the theory has already been the subject of discussion in the columns of *The Canadian Engineer*. (See issues of September 25th, November 6 and November 27th, 1913.)

Chapter VI. institutes many comparisons of the stresses and deflections as calculated and as shown forth by actual tests. The close agreement of the results is considered by the authors a convincing justification of their theory. So far as floor panels are comparable in size and proportions with those tested, the methods of calculation adopted will probably closely predict the actual behavior of the tested floors, but with any appreciable variation from these proportions the theory propounded by the authors would not likely receive such strong support.

Moments in two-way and four-way flat slabs are fully discussed in Chapter VII.

Chapter VIII. deals with columns and Chapter IX. with foundations. The remaining chapters cover the elements of economic construction and cost of reinforced concrete work, reinforced concrete as a fireproof form of construction, concrete under disintegrating forces, finishing, the relation of the engineer and the constructor to concrete building work, and many other matters.

As a general text for reinforced-concrete construction the book is inferior to at least two well-known treatises. Except so far as it applies to flat-slab construction, it is not so valuable a work on building construction in reinforced concrete as one of the books mentioned above. For those who have to do with flat-slab construction, however, the book is invaluable, but its usefulness so far as other forms of construction are concerned, is limited.

Mechanism of Steam Engines. By Prof. W. H. James and M. W. Dole, of the Massachusetts Institute of Technology. Published by John Wiley and Sons, New York; Canadian selling agents, Renouf Publishing Company, Montreal. First edition, 1914. 170 pages, 183 illustrations, 6 x 9 ins., cloth. Price $2.00 net. (Reviewed by R. W. Angus, Professor of Mechanical Engineering, University of Toronto).

This book is intended as an elementary treatment of the kinematics of steam engines and turbines. It discusses only the mechanisms and some of the resulting motions without any effort to deal with the properties of steam, and must not be mistaken for a general book on steam engines.

After a brief introduction a general description of the simple engine and indicator are given along with some illustrations. Chapters II., III. and IV. deal with descriptions and sectional illustrations of several simple valves and the analysis of the valve motions by diagrams, the Zeuner and Reuleaux valve diagrams being largely used, a knowledge of the principles of these diagrams being practically assumed as only very brief proof is given. The solutions of a number of problems are worked out in the book.

Chapters V. and VI. deal with the different methods of controlling engines either by throttling or automatic cut-off governor or by means of riding cut-off, corresponding valve diagrams being shown. Other chapters treat of multiple valve engines, e.g., Corliss, link motions and valve setting.

The remaining two chapters, X. and XI., are entirely devoted to steam turbines and their governors and valve mechanisms, the treatment being entirely descriptive.

Structural Engineers' Handbook. Data for the Design and Construction of Steel Bridges and Buildings. By Milo S. Ketchum, C.E., Dean of the College of Engineering and Professor of Civil Engineering, University of Colorado. Published by McGraw-Hill Book Co., New York City. First edition, 1914. 896 pp., 400 illustrations, 260 tables, 6 x 9 ins. Flexible leather. Price $5.00 net.

As the name implies, the handbook is expressly for the structural engineer, but its service extends itself to the student or, as the author states, "engineer who has had a thorough course in applied mechanics and the calculation of stresses in structures. One feature of the work that meets with approval at first sight is the size of book chosen, as we are more disposed to consider the 6 x 9-inch page as a standard. This size of page has proved a great factor in the book under consideration, as it has permitted a clear portrayal of diagrams, as well as an easily read type in large but important tabulated quantities. The printing and binding are excellent, and the index, which in the opinion of the reviewer requires more attention in a handbook than it usually receives, will be found exceedingly serviceable.

Proceeding into the subject-matter of the work, the chapters are found to be unusually complete and are here and there supplemented by carefully selected lists of references to which authorities the engineer may betake himself, if desired, for more detailed information.

The scope of the handbook, according to chapter headings, is as follows: Steel Roof Trusses and Mill Buildings; Steel Office Buildings; Steel Highway Bridges; Steel Railway Bridges; Retaining Walls; Bridge Abutments and Piers; Timber Bridges and Trestles; Steel Bins; Steel Grain Elevators; Steel Head Frames and Coal Tipples; Steel Stand Pipes and Elevated Tanks on Towers; Structural Drafting; Estimates of Structural Steel; Erection of Structural Steel; Engineering Materials; Structural Mechanics, and the Design of Steel Details. The book is divided into two parts, the first including (as the above chapter headings suggest) a discussion of the design of structures, together with data and details for the design of steel bridges and buildings; and the second part containing tables for structural design, including those giving the properties of rolled sections, and of built-up sections for chords, columns, struts, plate girders, etc., and data for standard structural details.

The author defines it to be a source book and not a treatise. He thus defines the function of a handbook, and it is evident that he has kept constantly in view the field which he desired the book to cover. Structural engineers, designers, draftsmen and students of the subjects of which it treats, cannot afford to overlook this handbook.

Mechanical Properties of Wood. By Samuel J. Record, M.A.M.F., assistant professor of Forest Products, Yale University, Forest School. Published by John Wiley and Sons, New York City; Canadian selling agents, Renouf Publishing Company, Montreal. First edition, 1914. 165 pp., 52 half-tone illustrations, 6 x 9 inches, cloth. Price $1.75 net.

Students of forestry to whom a knowledge of the technical properties of wood is essential, will find this a most instructive volume, quite free from highly technical treatments, and, in fact, quite readable by anyone interested in wood. An important feature of the work is the inclusion therein of a discussion of the factors affect-

ing these mechanical properties, and the methods of timber testing.

The work is presented in three parts, the first, the mechanical properties of wood, taking up fundamental considerations, tensile compressive, shearing and transverse strengths, toughness, torsion, hardness, and cleavability. The second part deals with factors affecting the mechanical properties of wood, such as rate of growth, weight, density, color, knots, insect and fungus injuries, temperature, preservatives, etc., etc. Part III. is devoted to timber testing, and takes up, forms of material used, moisture determination, machinery appliances, beam testing (large and small), and tests for impact, hardness, cleavage, tension, spike-pulling, etc. One appendix gives a sample working plan of the U.S. forest service. Another gives strength values for structural timbers. A bibliography in three parts well portrays the extent of literature on the subject.

Cement Specifications. By Jerome Cochrane, B.S., C.E., M.C.E. Published by D. VanNostrand Company, New York. First edition, 1912. 101 pp., illustrated, 6 x 9 ins., cloth. Price $1.00 net.

According to the full title of this work, it is a treatise on cement specifications, including the general use, purchase, storage, inspection and test requirements of Portland, natural, puzzolan (slag), and silica (sand) cement, and methods of testing and analysis of Portland cement. In the compilation of the work the author expresses himself as having endeavored at all times to present a set of specifications that would not only be consistent throughout, but which, at the same time, conform to modern practice. He recognizes the futility of endeavoring to draw up specifications which will meet all conditions of engineers and all constructional and manufacturing conditions of actual work, and he observes that it was useless to expect that all provisions incorporated in the specifications would be applicable to every class of construction work. This is mentioned by the way, for the reader will find that the presentation of the subject, growing in importance as the uses of cement are magnified, is clear, complete, and one well worthy of reference.

Besides the introduction, the divisions of the book are as follows: General Conditions Governing Use of Cement; Furnishing Cement to the Contractor; Purchase of Cement from Manufacturers; Delivery and Storage; Inspection and Tests; Test Requirements; Methods of Testing; Significance of Tests; Methods of Chemical Analysis; Bibliography of Specifications; same of Foreign Specifications.

Materials of Machines. By Albert W. Smith, director of Sibley College, Cornell University. Published by John Wiley and Sons, New York City; Canadian selling agents, Renouf Publishing Co., Montreal. Second edition, 1914. 215 pp., 36 illustrations, 5 x 7½ ins., cloth. Price $1.25.

The first edition of Prof. Smith's work was published about twelve years ago. The subject matter has been entirely re-written and brought up to date for the present edition. Its title may be better defined by stating that it is an elementary treatise on metallic materials used in the construction and operation of machines. This is presented in two parts, the first dealing with the manufacture of materials, to which four chapters are devoted, viz., Preliminary Considerations of Fuels; Electric Furnaces; Refractory Materials; Outline of the Metallurgy of Iron and Steel; and, the same of copper, lead, tin, zinc and aluminum. The second part deals with the physical properties of materials, as follows: Testing Materials; The Equilibrium of Iron and Carbon; Cast Iron; Steel; Heat Treatment of Steel; Non-ferrous Alloys; Selection of Materials for Machines. The first part is written as an essential preliminary to the study of the second, while the second part presents some very desirable information for those who design, construct and operate machines. The information which this book contains is not easily collected, and its presentation in a single, small volume will be welcomed with considerable interest by engineers interested any way in the construction and operation of machines.

PUBLICATIONS RECEIVED.

Ontario Railway and Municipal Board.—Eighth annual report (to December 31st, 1913). 588 pp.; 6 x 9 ins.

Weights and Measures, Gas and Electricity.—Part 2, reports and statistics of inland revenues, Canada, 1914. 54 pp.; 6 x 9 ins.

Municipal Department of Hygiene and Statistics of Montreal.—Report for 1913, by Dr. S. Boucher, M.O.H. 104 pp.

United States Bureau of Mines.—Fourth Annual Report of the Director, for year ending June 30th, 1914. 101 pp.; 6 x 9 ins.

Agriculture and Immigration.—Report of Department, Province of Manitoba, for 1913. 125 pp.; illustrated; 6 x 9 ins.

Determination of the Co-efficient of Expansion of Mercury at Low Temperatures.—By C. B. James. A reprint from the transactions of the Royal Society of Canada. 8 pp.; illustrated.

Tide Tables.—Two bulletins, prepared by W. Bell Dawson, superintendent, Tidal and Current Survey, Department of Naval Service, Canada. One relating to Eastern coasts and the other to Western coasts.

Analyses of Mine and Car Samples of Coal.—Bulletin 85, United States Bureau of Mines, relating to samples collected in 1911, 12 and 13, giving tabulated analyses and descriptions of samples by states and counties. Illustrated.

The Crow's Nest Volcanics.—By J. D. MacKenzie. Published by the Geological Survey, Department of Mines, Canada, as museum bulletin No. 4. It relates to general geology, petrography, discussion, summary and conclusions. 37 pp.; illustrated.

Commission of Conservation, Canada.—Fifth Annual Report, 1914, giving proceedings of the fifth annual meeting, held at Ottawa, January, 1914. 288 pp.; illustrated; 6 x 9 ins.; cloth. James White, assistant to chairman, Commission of Conservation, Ottawa.

Department of Naval Service.—Annual Report for year ending March 31st, 1914. 100 pp.; illustrated; 6 x 9 ins. It contains reports on naval branch fisheries protection service, survey of tides and currents, hydrographic survey branch and radio telegraph branch.

The Expansive Force of Ice.—(See *The Canadian Engineer*, December 10th, 1914, page 741.) A 20-page reprint from the transactions of the Royal Society of Canada. Prepared by Prof. H. T. Barnes, and Messrs. J. W. Hayward and Norman M. McLeod. Illustrated.

Notes on the Sampling and Analysis of Coal.—By A. C. Fieldner for the United States Bureau of Mines. Published as technical paper 76. 61 pp.; illustrated. Collection of samples; methods of analysis; interpretation and accuracy of analytical results; classification, etc.

Ontario Highway Legislation.—A compilation of Ontario highway laws, prepared under the direction of Mr. W. A. McLean, commissioner of highways, and appended to his annual report on highway improvement, 1914. (See *The Canadian Engineer*, December 17th, 1914, page 767.)

Dundee Falls and Falls Village Developments.—A handsomely illustrated booklet, descriptive of these developments for S. D. Warren and Co. and Connecticut Power Co., respectively. Reprint from Stone and Webster Public Service Journal. S. and W. Engineering Corporation, New York.

Fire Prevention.—Reports on various activities of the British Fire Prevention Committee, 8 Waterloo Place, Pall Mall, London, S.W. 40 pp.; illustrated, including Committee's record for 1913; portable chemical fire extinguishers; self-contained smoke helmets; the Committee's inquiry office, etc.

Geographic Board of Canada.—Thirteenth Report, ending March 31st, 1914. It contains all decisions from inauguration of Board up to that date. Also list of counties in Canada and townships in Ontario, Quebec and Nova Scotia, and parishes in New Brunswick. As an appendix, it has an outline of the physical geography of Canada.

Analysis of Coal with Phenol as a Solvent.—A 41-page illustrated bulletin (No. 46), issued by the Engineering Experiment Station, University of Illinois, Urbana, Ill., prepared by S. W. Parr and H. F. Hadley. Deals with the division of bituminous coal with phenol as a solvent for resinic material while the cellulose residuum is insoluble.

American Society for Testing Materials.—Committee reports, being Part I. of the proceedings of the 17th Annual Meeting (1914). It includes reports on ferrous metals; non-ferrous metals; lime, cement and clay products; miscellaneous materials; preservative coatings, etc.; miscellaneous subjects. 484 pp.; illustrated; 6 x 9 ins. Secretary, Ed. Marburg, University of Pennsylvania, Philadelphia, Pa.

CATALOGUES RECEIVED.

Matheson Joint Pipe.—A handsomely illustrated 40-page booklet, descriptive of this system of piping for high and low pressures. Issued by the National Tube Co., Pittsburgh, Pa.

Directory of Piston Ring Sizes.—A 68-page booklet for users of automobiles, motor cycles, cycle cars, trucks, tractors, and engines. Issued by the Burd High Compression Ring Co., Rockford, Ill.

Variable Release Air-Brake Equipment. — A 12-page booklet describing this type of automatic air-brake equipment, its chief advantages, general design, operation, etc. Issued by the Canadian General Electric Co.

Drag-Line Excavators.—Leaflets descriptive of glasses, B, H, and K, of the Lidgerwood line, setting out specifications and illustrating the machine in use. Exclusive agents in Canada, Canadian Allis-Chalmers, Limited.

Lackawanna Deseaming Process for Rail Sections.—A bulletin published by the Lackawanna Steel Co. describing this method of improving the quality of rails. A most interesting discussion of the subject, well presented and carefully illustrated.

Worm-Gear Chain-Blocks.—A 4-page leaflet (Bulletin B 10) on the construction of a chain-block designed for a load of 60 tons, and regularly tested to 90 tons. Issued by the manufacturers, the Herbert Morris Crane and Hoist Co., Limited, Montreal and Toronto.

Oxy-Acetylene Welding and Cutting and its Applications.—An extensive publication issued by L'Air Liquide Society, Toronto, Montreal and Winnipeg, enumerating and illustrating the application of the Autogenous welding process in the different trades. Fully illustrated.

Hoisting Machinery.—A 144-page catalogue, well illustrated and durably bound. Published as Catalogue No. 3 of Marsh and Henthorn, Limited, Belleville, Canada. Sales agents, Mussens, Limited, Montreal. Fully descriptive of their types of hoisting engines and auxiliary apparatus.

Gas-Electric Motor Cars and Locomotives.—Bulletin No. 44,300; 8 pp.; illustrated; of special interest to railway men on branch line service of steam roads and on interurban railway service, to which this class of equipment is specially adapted, issued by the Canadian General Electric Co., Toronto.

Cochrane Multiport Valves.—A handsome, well-illustrated, 72-page catalogue of multiport valves for back-pressure service, atmospheric relief in vacuum service, flow service, and bleeder or extraction service. Catalogue 601. Harrison Safety Boiler Works. Selling agents in Canada, Canadian Allis-Chalmers, Limited, Toronto.

REPORTS OF COMMITTEES, CANADIAN SOCIETY OF CIVIL ENGINEERS.

THE Council of the Canadian Society of Civil Engineers has recently issued, for the consideration of members prior to the Annual Meeting of the Society in Montreal, January 26-28, 1915, the reports of a number of standing committees. Ample opportunity is thus being given to each member for acquiring a thorough knowledge of the findings, as submitted, so that intelligent action may be taken with regard to them when they come up for consideration at the afternoon session of the first day of the meeting. We present herewith a summary of the submitted reports.

Report of Committee on Rails.—The committee, consisting of Mr. H. G. Kelley, chairman, and Messrs M. J. Butler, G. A. Mountain, J. M. R. Fairburn and A. F. Stewart, recommended the adoption by the Society of the rail specifications of the American Railway Engineering Association. The investigations and experiments of the engineers of the committee of that association have been carefully studied by the above committee and their findings, covering both chemistry and mill practice, have produced the specification now well known as the "A.R.E.A." rail specification. A copy of it is presented.

Report of Committee on Track.—This committee consists of Mr. H. R. Safford, chairman, and Messrs. W. A. Bowman, C. B. Brown, S. B. Clement, A. Crumpton, F. P. Gutelius, R. M. Hannaford, R. L. Latham, D. MacPherson, E. W. Oliver, A. F. Stewart, J. G. Sullivan, C. Warnock and A. C. MacKenzie.

The committee devoted itself to the study of two subjects: (1) Size and spacing of ties. (2) The proper method of measuring efficiency of track forces. The study of another subject, viz., Terminal facilities in cities for freight, including private sidings and cartage arrangements was, with the consent of the Council, postponed for the present. For a study of the two above-mentioned subjects the committee presents forms for the purpose of collecting from the membership as much needed data as possible bearing upon the question of track maintenance. Thereby relative values of the various features entering into track work may be arrived at, the idea behind the study being to work out some basis for equating these values as an aid to the proper distribution of allowances for track work.

The committee expresses its belief that the present method of apportioning track expenditures is too general and that no well-defined means exists for properly measuring the relative needs of the different sections and districts, with the vastly different conditions which affect cost. A good deal of data must be collected to this end.

Progress is reported on the specifications for the size and spacing of rails and discussion is invited. Suggested programs for study are presented. (For the 1913 report of the committee on track the reader is referred to *The Canadian Engineer* for January 22, 1914, page 203).

Report of Committee on General Clauses and Specifications.—This committee consists of Mr. H. Holgate, chairman, and Messrs. E. G. M. Cope, R. de L. French, W. Chipman and J. G. G. Kerry. A carefully compiled form of general clauses is presented, from which it is evident that much correspondence, study, revision and alteration has been devoted to the subject. By the use of it, it is suggested, the form of contract and of specifications may be very much abbreviated.

The committee recommends that all contracts should embrace, in one document: (1) The agreement or contract itself; (2) the tender or a certified copy of it; (3) the specification; (4) the general clauses; (5) the signed drawings as tendered on, and (6) any modified drawings agreed to prior to signing of contract.

Report of the Committee on Concrete and Reinforced Concrete.—The committee consists of Mr. Walter J. Francis, chairman, and Messrs. S. Baulne, E. Brown, E. Brydone-Jack, J. Galbraith (deceased), P. Gillespie, H. M. Mackay, E. S. Mattice, C. N. Monsarrat, Michael Morssen, P. B. Motley, and H. Rolph.

This committee presented a draft at the annual meeting last January of the standard general specifications for concrete and reinforced concrete. It brought forth a certain amount of discussion at the meeting. (For the draft and this discussion relating thereto, see *The Canadian Engineer*, January 22, 1914, page 198, and February 5, 1914, page 274, respectively). Subsequent discussions from branches and individual members were invited and varied contributions totalling 30,000 words, were received.

In his letter of transmittal, Mr. Francis refers to the loss the committee suffered in the death of Dr. John Galbraith.

The series of tests advocated at the last annual meeting were made during the year. The Atlas Construction Company, Limited, through their president, Mr. C. M. Morssen, M. Can. Soc. C.E., a member of the committee, made sixty-four 8 in. x 12 in. concrete beams, 11 ft. long. In the laboratories of McGill University these beams were tested under the direction of Prof. H. M. MacKay and Prof. Ernest Brown, both members of the committee. All the beams were tested to destruction, some at the age of two months and the balance at the age of three. The results were most conclusive, and were subsequently considered by the committee. Since that time weekly sessions of the committee were held, and the draft was analyzed and deliberated upon in greatest detail.

Nickel in the form of nickel sulphate and as metallic nickel is saved from the electrolytes used in refining blister copper. Most, if not all blister copper carries a little nickel which goes into solution, and gradually accumulates in the electrolyte. During 1913, according to the United States Geological Survey, an equivalent of 481,565 lbs. of nickel, valued at $79,393, was thus saved by refineries. About one-fourth of the product was produced as electrolytic nickel.

Coast to Coast

Ottawa, Ont.—A new road is proposed between Ottawa and Prescott, to be financed in a manner similar to the Toronto-Hamilton road. It is estimated to cost $10,000 per mile, and is 58 miles in length.

Ottawa, Ont.—Mr. D. W. McKughlin, engineer-in-charge of the Hudson's Bay terminal works at Port Nelson, reports that splendid progress has been made on the terminal and harbor works during the past season.

Vancouver, B.C.—As a result of some vessel dragging an anchor or grappling-hook while passing through the First Narrows one of the two 18-inch water mains recently laid across the bed of the Narrows, and supplying the city with 3,000,000 gallons of water per day from Capilano, was pulled apart, and the other dislodged from its proper position.

Saanich, B.C.—The long-proposed extension and improvement of the Lake Road in South Saanich municipality is about to become a reality. Tenders are already in hand, and it is expected that the contract will be awarded without delay. The estimated cost is $29,500. This improvement involves the construction of a subway under the Victoria and Sydney Railway, and a culvert to drain surplus water from the Swan Lake district. Considerable grading is required on a section of the road about 6,000 yards in length. Another road improvement in this vicinity entails the expenditure of about $30,000 on Shelbourne Street.

Port Arthur, Ont.—The Western Dry Dock and Shipbuilding Co., Limited, of Port Arthur, have taken out a building permit for a forge shop to cost about $30,000. Besides the construction of steamships, this company will manufacture engines and boilers of all kinds, hoisting and excavating machinery, structural steel and cabinet work. In the last two years they have turned out several large steamships, and are well equipped for the manufacture of the above machinery. This company have also received a large order from the British Government for shells and other war materials.

Edmonton, Alta.—The next piece of construction that will be effected by the Canadian Northern Railway is reported to be a branch line from Edmonton to Peace River Landing or Dunvegan the key to the Peace River and Grande Prairie country. Already a line from Edmonton has been completed for a distance of sixty miles to a point in the immediate neighborhood of the source of the Prairie River. From this point the branch will be directed north-west to either of the two places, thus giving an all-rail route from Edmonton to the homesteading country in the Peace River and Grande Prairie district.

Moose Jaw, Sask.—Bills before the Dominion government asking for new railway charters include one relating to the Brule, Grand Peace River Railway Co., seeking the right to construct railway, telegraph and telephone lines, commencing at Brule Lake, on the main line of the Grand Trunk Pacific and Canadian Northern Railways, north-westerly to Grande Prairie, thence north-westerly to a point in British Columbia, connecting with the terminus of the Pacific and Great Eastern Railway at or within the Peace River block, also commencing at Grande Prairie northerly to the Pacific, Peace River and Athabasca Railway at or near the point where the railway crosses the Montagneuse River, passing at or near Spirit River settlement, and crossing the Peace River at or near Dunvegan, approximately 400 miles in all.

PERSONAL.

Capt. A. J. McPHERSON, Deputy Minister of Public Works for the Province of Saskatchewan, is commanding the Regina Field Company of Canadian Engineers.

A. C. MORRISON, of Ottawa, has been appointed inspector of gas and electricity for the Ottawa Inspection district, to succeed Mr. A. A. Couvrette, resigned.

K. S. MacLAUGHLIN, B.A.Sc., superintendent of Metals Chemicals, Limited, Welland, Ont., is suffering from serious injuries sustained in a laboratory explosion last week.

R. S. WINTER, of Medicine Hat, Alta., has been appointed gas superintendent in succession to Mr. Wm. Craft, who has resigned from this civic position owing to ill-health.

G. H. FERGUSON has been appointed Minister of Lands, Forests and Mines for the Province of Ontario, assuming the position held by Premier Hearst prior to the latter's being appointed Premier.

Capt. T. C. IRVING, M. Can. Soc. C.E., of the Irving-Moffat Electric Steel Co., and vice-president of Robert W. Hunt and Co., will command the divisional engineers of the Canadian expeditionary force, about to leave Salisbury Plain for service in France and Belgium.

H. C. BARBER has joined the sales force of the Standard Underground Cable Co. of Canada, Limited, of Hamilton. Mr. Barber is a graduate of the Faculty of Applied Science of the University of Toronto. He has been with the Toronto Hydro System and the Hamilton Hydro Department, also with the Packard Electric Company, of St. Catharines.

E. G. MATHESON, M. Can. Soc. C.E., superintendent for the Foundation Co., Limited, on the construction of the substructure for the Canadian Pacific Railway bridge over the Pitt River, described the undertaking in an illustrated address given at the regular meeting of the Vancouver Branch of the Canadian Society of Civil Engineers, held on December 18th last.

OBITUARY.

At Kingsville, Ont., Mr. A. W. Weatman, superintendent of the W.E. and L.S. Railway, was electrocuted last week while engaged in putting a snowplough into service.

Thos. Blackwood, Deputy Inspector of Mines in the Province of Nova Scotia, lost his life by an explosion in one of the shafts at Stellarton, N.S., last week. Mr. James Brown, superintendent of the mine for the Acadia Coal Co., accompanied Mr. Blackwood on his trip of inspection, and was also killed, and Mr. Alex. Sutherland, manager of the mine, had a very narrow escape.

The death occurred on December 17th of Mr. F. X. Dion, president of the Lauzon Engineering Co., Limited, engineers and contractors, of Levis, Que. The late Mr. Dion was a well-known figure in business circles in the Province of Quebec.

The extraction of gasoline from natural gas, according to a bulletin issued by the United States Geological Survey, has become one of the chief adjuncts of the natural gas industry in the United States. The production in 1913 was almost double that in 1912.

Recent elections to the class of Associate Member in the American Society of Civil Engineers included the names of Mr. G. W. Harris, office engineer, Mackenzie, Mann and Co., Limited, Port Arthur, Ont.; Mr. C. S. Millard, manager and chief engineer for Francis S. Swales, architect, Vancouver, B.C.; and Mr. L. R. Thomson, designer, Dominion Bridge Co., Limited, Montreal.

PRESERVATION OF RAILWAY TIES.

At a recent meeting of the Society of Chemical Industry in Montreal two interesting papers were read on the subject of timber preservation. Dr. John S. Bates, director of the Forest Products Laboratories of Canada, gave an account of the work which has been done in the laboratories, and summarized investigation of conditions governing the durability of timber. The work has included a study of pulp and paper-making. Mr. W. B. Campbell, B.Sc., a member of the laboratory staff, read a paper on the preservation of wood, dealing with the various forms of rot which affect timber and clearly showed that the best method of increasing the durability of timber used for railway ties was to impregnate the wood with some substance poisonous to the organism that caused rot. In this connection he mentioned substances soluble in water, such as zinc chloride, and substances oily in nature, such as creosote oil. Mr. Campbell dwelt upon the advances of properly creosoted wood block paving, etc. The papers were followed by some valuable discussion, some of the participants being Prof. W. D. Walker, of Queen's University; Dr. Milton Hersey, Mr. J. A. DeCew, Mr. Fred. B. Brown, and Dr. S. Kirsch.

A committee was formed to investigate the feasibility of rendering wood fireproof, and to make specific proposals to the Government for legislation that would encourage the establishment of such a chemical study. The following were appointed to this committee: Mr. T. H. Wardleworth, chairman of the local branch of the Society; Dr. R. F. Ruttan, Dr. Milton Hersey, Mr. J. A. DeCew, Mr. C. F. Bardorf and Mr. A. G. Spencer.

COMING MEETINGS.

AMERICAN FORESTRY ASSOCIATION. — Annual meeting to be held in the Woolworth Building, New York City, January 11th, 1915. Secretary, P. S. Ridsdale, Washington, D.C.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.—Annual Convention to be held at the King Edward Hotel in Toronto, January 26, 27, and 28, 1915. Secretary, G. C. Keith, 32 Colborne Street, Toronto.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—Twenty-ninth annual meeting, to be held in Montreal, January 26th, 27th and 28th, 1915. Secretary, Prof. C. H. McLeod, 176 Mansfield Street, Montreal, Que.

AMERICAN CONCRETE INSTITUTE.—Eleventh Annual Meeting, to be held in Chicago, February 9th to 12th, 1915. Secretary, Edward E. Krauss, Harrison Building, Philadelphia, Pa.

EIGHTH CHICAGO CEMENT SHOW.—To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.

AMERICAN WATERWORKS ASSOCIATION. — The 35th annual convention, to be held in Cincinnati, Ohio, May 10th to 14th, 1915. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—Annual meeting to be held at the Iowa State College, Ames, Iowa, June 22nd to 25th, 1915. Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

In a paper read before the Duluth meeting of the American Peat Society, Dr. Peter Christianson calls attention to some of the possibilities of peat as a metallurgical fuel, especially in the iron and iron-ore industry of the Lake Superior iron district, that is, in the beneficiation or preliminary treatment, and in the smelting, of the ore.

IMPROVEMENT OF HIGHWAY CONTRACT WORK.*

By John J. Ryan,
Secretary, New York State Road Builders' Association.

LATE fall, winter and early spring are the best for highway lettings, inasmuch as the contractor has practically closed his work and has plenty of time to go over new jobs, being in a position to bid intelligently on these contracts. The municipality would gain by having lettings at these times, as they would receive more bids and, undoubtedly, fairer prices for work.

There seems to be a reluctance on the part of most highway departments to furnish information to bidders. Never yet has money been lost by allowing a contractor to know in advance all that there was to be known about a contract which was advertised for letting. In New York State it has been the practice, after advertising highway contracts, to furnish the contractors with the engineer's figures showing how the engineer has arrived at his estimate by computing basic prices, with profit allowance. While some of the old guard of contractors state that they prefer no engineer's estimates, yet, in general, the road builder in New York looks for these estimates on each road and checks up the same with his own idea of cost prices, making allowance for methods and supervision. It has yet to be found that New York lost any money by this procedure; rather has it benefited by it, because the contractor, when furnished with full information as to the contract, is in a position to bid closer and know what he is doing when bidding.

On the day appointed for the letting the bids should be in at a specified hour, opened at that time and read publicly, item by item, with the total amount of contract price. This practice advises the contractor immediately whether he is low, and he is in a position to make arrangements about plant, material and labor, pending the official award. This award should not be held up more than twenty-four hours, unless for some unforeseen cause. It ought not to take more than twenty-four hours to make a recapitulation of any number of highway bids. In New York State, where on one day they have as many as thirty roads with three hundred bidders, the checking up is done at the same time the bids are read, and the award is made that day or the next morning. This allows the contractor to arrange for his bonds and the other necessities in connection with the preliminary part of his contract.

Bonds and Monthly Estimates.—Performance bonds for highway contracts should exceed 50 per cent. of the contract price. Such a bond becomes a liability when the contractor signs it, and while it may be called paper liability, yet it has effect upon his credit and sometimes acts as a hindrance in securing other contracts. Some states ask for a bond of 100 per cent., which is quite needless and an inheritance of old and obsolete requirements.

The monthly estimate is the vital thing to the contractor. There can be no successful contract without prompt monthly estimates. These must not be irregular nor must they be pruned. Monthly payments to the builder are as food to the body. In some states 90% of the monthly estimates taken about the 20th of the month are paid before the first of the next month; that is, practically all monthly estimates are paid within 10 days.

When the first monthly estimate comes around the contractor should have his cost data and his monthly reports figured so that he knows how much work has been done and at what cost, and is in a position to take up the matter with the engineer. Together they can check up and agree upon what the estimate should be, so that there will be no deficiency when the check comes to the contractor.

*Read at the Atlanta Congress, Nov. 9-14, 1914.

CANADIAN PRODUCTION OF COAL IN 1913.

CANADA'S coal situation is very clearly portrayed by Mr. John McLeish, B.A., chief of the division of mineral resources and statistics, Department of Mines, Canada, in his recently issued report on the production of coal and coke in Canada during 1913. The coal fields and deposits, which are probably the most extensive and best known of the country's mineral resources, are found principally in the coast provinces and in Alberta. The central provinces, Ontario and Quebec, in which the major portion of Canadian population is still concentrated, and which are without coal fields, find it more economical to use coal from Ohio and Pennsylvania. Besides, Pennsylvania anthracite is used in great quantity in eastern as well as central Canada.

Canadian coal is chiefly bituminous and lignite, although an output of about 200,000 tons of anthracite is produced yearly at the Bankhead mines in Alberta.

Mr. McLeish gives the total production of coal in 1913 to be 15,012,178 short tons, valued at $37,334,940, or an average of $2.49 per ton. This production was obtained by about 227 operating companies employing an average of 27,917 men at a wage cost of approximately $22,065,141. Compared with 1912, in which year the production was 14,512,829 short tons, valued at $36,019,044, an increase is shown of 499,349 tons or 3.44 per cent. in quantity. These values are partially estimated or assumed since complete returns have not been received with respect to the total value received for coal sold. In the case of Nova Scotia an average value of $2.50 per long ton is placed upon the total production, while for British Columbia an average value of $3.50 per long ton is used. The values placed upon the Alberta production are those furnished by the operating companies.

The total exports of domestic coal from Canada in 1913 were 1,562,020 tons valued at $3,961,351 as compared with 2,127,133 tons valued at $5,821,593 in 1912. There is also a small export of coal "not the produce of Canada."

The total imports of coal in 1913 were 18,201,953 tons valued at $47,949,119, as compared with imports in 1912 of 14,595,810 tons valued at $39,478,037.

The total consumption of coal in 1913 was 31,582,545 tons or 4.07 tons per capita, as compared with 26,934,800 tons or 3.59 tons per capita in 1912.

The increased use of oil fuel for locomotives in British Columbia and for coast vessels has in some slight measure reduced the market for coal in western Canada. According to statistics published by the Department of Railways and Canals, the total consumption of coal in locomotive boilers during the twelve months ending June 30, 1913, was 9,045,625 tons, which is equivalent to very nearly one-third the total consumption of coal in Canada. During the twelve months ending June, 1912, there was used for locomotives 1,729,577 gallons of oil, whereas during the twelve months ending June, 1913, the quantity so used was 31,087,252 gallons. This consumption of oil in 1913 would probably be equivalent to about 310,000 tons of Nanaimo coal and, taken in conjunction with the oil used on coast vessels, indicates in some degree the extent to which coal has been displaced as a fuel in this market.